DISCUSSION PAPER SERIES

DP15006

EXPLAINING MONETARY SPILLOVERS: THE MATRIX RELOADED

Jonathan Kearns, Andreas Schrimpf and Fan Dora XIA

FINANCIAL ECONOMICS

INTERNATIONAL MACROECONOMICS AND FINANCE

MONETARY ECONOMICS AND FLUCTUATIONS

ISSN 0265-8003

EXPLAINING MONETARY SPILLOVERS: THE MATRIX RELOADED

Jonathan Kearns, Andreas Schrimpf and Fan Dora XIA

Discussion Paper DP15006
Published 07 July 2020
Submitted 30 June 2020

Centre for Economic Policy Research
33 Great Sutton Street, London EC1V 0DX, UK
Tel: +44 (0)20 7183 8801
www.cepr.org

This Discussion Paper is issued under the auspices of the Centre's research programmes:

- Financial Economics
- International Macroeconomics and Finance
- Monetary Economics and Fluctuations

EXPLAINING MONETARY SPILLOVERS: THE MATRIX RELOADED

Abstract

This paper relies on a high-frequency identification approach to provide new insights into monetary policy spillovers by major central banks. Our long and broad sample (1999-2019, from four major economies to 47 advanced and emerging market economies) allows us to accurately identify the properties of spillovers and to shed light on different transmission channels. We find that spillovers by the Fed to foreign interest rates are large, but more surprisingly, document an intensification of spillovers by the ECB over time. Spillovers are more significant to bond yields in advanced economies than they are to those in emerging markets. Differentiating across key spillover channels, we find strongest support for a financial links channel, but weaker evidence for the macroeconomic links channel and FX regime channel.

JEL Classification: E44, F36, F42, F65

Keywords: monetary policy spillovers, high-frequency data, Financial Integration

Jonathan Kearns - KearnsJ@rba.gov.au
Reserve Bank of Australia

Andreas Schrimpf - andreas.schrimpf@bis.org
Bank for International Settlements and CEPR

Fan Dora XIA - dora.xia@bis.org
Bank for International Settlements

Explaining Monetary Spillovers: The Matrix Reloaded*

Jonathan Kearns
Reserve Bank of Australia
KearnsJ@rba.gov.au

Andreas Schrimpf
BIS & CEPR
andreas.schrimpf@bis.org

Dora Fan Xia
BIS
dora.xia@bis.org

First version: 20th November 2018
This version: 30th June 2020

*We are grateful to Ben Cohen, Stijn Claessens, Mathias Drehmann, Georgios Georgiades, Enisse Kharroubi, Tim Kroencke, Hyun Song Shin, and seminar and conference participants at BIS, Bank of Israel, Reserve Bank of Australia, University of Geneva, University of Lugano, University of Neuchatel, University of Melbourne, University of Sydney, the 2017 Geneva International Macroeconomics and Finance Workshop, the 2018 CEBRA conference and the 2019 RECA Money-Macro-Finance conference, for helpful comments and suggestions. Research assistance by Alan Villegas and Nicolas Lemercier is gratefully acknowledged. The views in this article are those of the authors and do not necessarily represent those of the Bank for International Settlements (BIS) or the Reserve Bank of Australia (RBA).

Explaining Monetary Spillovers: The Matrix Reloaded

Abstract

This paper relies on a high-frequency identification approach to provide new insights into monetary policy spillovers by major central banks. Our long and broad sample (1999-2019, from four major economies to 47 advanced and emerging market economies) allows us to accurately identify the properties of spillovers and to shed light on different transmission channels. We find that spillovers by the Fed to foreign interest rates are large, but more surprisingly, document an intensification of spillovers by the ECB over time. Spillovers are more significant to bond yields in advanced economies than they are to those in emerging markets. Differentiating across key spillover channels, we find strongest support for a financial links channel, but weaker evidence for the macroeconomic links channel and FX regime channel.

JEL Classification: E44; F36, F42, F65

Keywords: Monetary Policy Spillovers; High-frequency Data; Financial Integration

1 Introduction

It is well documented that interest rates co-move across countries. The extent of this co-movement, and the underlying drivers, are more contentious but are important for many reasons. The greater the co-movement of a country's interest rates with foreign rates that is unrelated to domestic conditions, the weaker the control by the central bank over its domestic financial conditions, diminishing its ability to achieve its policy objectives. Interest rate co-movement is also an important channel through which financial shocks can propagate internationally. In addition, a large amount of co-movement may diminish the diversification opportunities available to international investors in fixed income markets.

Concerns regarding co-movement have been particularly prominent surrounding quantitative easing (QE). The exceptionally large expansions in major central banks' balance sheets during and after the global financial crisis (GFC), and again with the Covid-19 crisis, explicitly sought to compress domestic long-term yields. QE policies are commonly believed to have spilled over to very easy financial conditions and low yields in other countries, which, at least in the GFC, may not have been warranted given domestic economic conditions in those economies.

While many papers have documented some co-movement of interest rates internationally, extant work often struggles to cleanly identify whether the co-movement stems from spillovers in a causal sense or rather from extraneous common drivers. Further, prior work has to date not demonstrated consistently which types of monetary policy surprises generate spillovers, which countries' central banks trigger spillovers, and which countries are most prone to be recipients, and why.

In this paper, we contribute to the literature on interest rate spillovers in three ways. First, we precisely estimate the spillovers from one country's interest rates to others by using cleanly identified monetary policy surprises from high-frequency interest rate changes.[1] Using intraday data to measure the interest rate change in response to a monetary policy announcement in the originating country ensures exogeneity and thus enables us to pin down the direction of spillovers in a causal sense. As the impact of monetary policy on financial markets is multi-faceted, we also move beyond the existing literature by identifying three components to a monetary policy surprise and tracing their respective

[1] Note that throughout this paper, we use the term 'spillovers' to encompass changes in a country's interest rate that are in *direct* response to those in another country's interest rate that is triggered by monetary policy news in that country.

impact on foreign interest rates. We look at (i) a 'target' policy rate surprise, (ii) a surprise to the expected 'path' of policy, and (iii) a 'long-rate' surprise. This setup encompasses the wide range of information contained in central bank announcements, and allows us to use a sample that covers both the period of 'normal' interest rate policies prior to the financial crisis, and for some more recently, and the period of 'zero' policy rates that followed in the QE period.

Second, we investigate for which interest rates and country combinations spillovers occur, by using a rich set of data in both the time-series and cross-sectional dimensions. We perform our analysis for monetary policy surprises originating from four major central banks (Federal Reserve, ECB, Bank of Japan and Bank of England). We look beyond the 'matrix' of monetary policy spillovers among these four currency areas, to consider an even larger matrix where we look at interest rate responses of 47 advanced and emerging market economies (EMEs). In our tests, we analyze spillovers for both short- and long-term interest rates. A feature of our research design is the large cross-sectional dimension, which not only offers benefits in terms of power but also allows to better shed light on the nature and extent of interest rate spillovers.

Third, our comprehensive dataset (1999-2019, 47 countries) enables use to thoroughly test when interest rate spillovers occur, to what extent they vary over time, and through which types of monetary policy surprises. And, importantly, it allows us to assess through which channels those spillovers occur. We propose three channels: (i) macroeconomic links, (ii) FX regime, and (iii) financial links. To estimate the importance of these channels we use a comprehensive set of financial and economic data for our broad panel of countries, encompassing bilateral and aggregate economic and financial links as well as country-specific factors. With these data at hand, we explore the economic and financial conditions that lead to stronger (or weaker) interest rate spillovers.

Several novel results from our analysis are worth highlighting. Importantly, in contrast to conventional wisdom, we identify that spillovers are larger to advanced economies (that are well-integrated in global capital markets) than they are to emerging markets. While it is known that there are strong spillovers originating from Federal Reserve monetary policy announcements, we find surprisingly large spillovers also originating from the ECB. Fed spillovers have more or less been constant over time as we show in the paper—also QE spillovers have not been materially different than those triggered by

conventional policy. ECB spillovers have gained in importance over time, but mostly affect advanced economies' interest rates. That said, the Fed clearly stands out in terms of the global importance of the spillover effects it generates, and none of the other central banks has as large an effect on EMEs. Spillovers from the other major central banks, the Bank of Japan and the Bank of England, are at most mild, and their importance is more regionally confined.

The spillovers we document are much more prevalent for long-term interest rates, while short rates do not consistently respond to foreign monetary policy news. This suggests that central banks have been able to retain a significant degree of autonomy in their interest rate policies (consistent, e.g. with Obstfeld, 2015), despite the forces of the global financial cycle.[2] One may argue, however, in line with Rey (2013) that it is particularly longer-term rates that determine financial conditions. Our results are thus consistent with the view that the power of central banks to determine domestic financial conditions is limited by the presence of international spillover effects.

We obtain a clear picture regarding the main channels through which the strength of spillovers across countries can be understood. There is some empirical support for all three channels we identify, but to different degrees. For the macroeconomic channel, there is some evidence that there are stronger spillovers between countries that trade more with each other and have more synchronous GDP growth or inflation dynamics. There is partial support for the FX regime channel. However, and in support of the financial linkages channel, 'financial openness' unambiguously emerges as the strongest factor in explaining the sensitivity of a country's interest rates to monetary policy surprises in the major advanced economies. In explaining interest rate sensitivity, financial openness is best captured by bilateral portfolio debt flows and the amount of the country's debt denominated in the currency of the spillover originator country, although the results are robust to using alternative measures of financial openness.

The remainder of the paper is structured as follows. In Section 2 we outline the channels through which policy in one country can spill over (in the broad sense of the word) to other countries' interest rates and discuss the related literature. In Section 3 we provide a roadmap of our methodology for detecting spillovers and testing the different spillover channels. In Section 4 we outline the detailed

[2] Miranda-Agrippino and Rey (2015) suggest U.S. monetary policy is a key driver of the global financial cycle. See e.g. Cerutti, Claessens, and Rose (2019) for new evidence and a sceptical view regarding the existence of a global financial cycle, as conditions in the core do not explain a large share of global capital flows.

data we use to first identify spillovers and then to test the channels. We then present our results on global spillovers and their main drivers in Sections 5 and 6, respectively. We then conclude.

2 Why do monetary policy spillovers occur?

2.1 Spillover channels

Yield curves can be influenced by a range of domestic and international factors.[3] In most financial systems, short-term money market rates are determined by central bank policy actions. Central banks' policy mandates and goals differ across countries, but most respond to macroeconomic conditions (in particular inflation, and often unemployment or the output gap) and, for some, exchange rate considerations matter too. Central banks' control over long-term rates is usually significantly weaker under most monetary operating frameworks.[4] Long-term government bond yields reflect not only current and expected short-term rates, but also risk premia (in particular, term premia and in some cases, e.g. emerging markets, also credit risk premia). Based on these broad macroeconomic and financial determinants of short and long interest rates, we identify *three potential channels* through which spillovers can occur from interest rates in an originator country to those in the recipient country.

(a) Macroeconomic links. Monetary policy announcements in the originator economy may reveal new information on economic conditions in that economy, as suggested by Campbell, Evans, Fisher, and Justiniano (2012) and Nakamura and Steinsson (2018). This may in turn lead investors to update their expectations of macroeconomic conditions and the future evolution of the policy rate in the recipient country given the macroeconomic links between the two economies. These links can result from trade flows, where for example stronger growth in the originator economy results in more imports from the recipient country, and hence stronger growth in that country. The links can also encompass a broad range of business and information flows that manifest as co-movement in business cycles (see, for example, Kose, Otrok, and Whiteman (2003) and Baxter and Kouparitsas (2005)) and/or inflation dynamics (see, for example, Ciccarelli and Mojon (2010) and Neely and Rapach (2011)). For example,

[3] See, e.g., Diebold, Piazzesi, and Rudebusch (2005), Gürkaynak and Wright (2012), or Dahlquist and Hasseltoft (2013).

[4] A notable exception is the Bank of Japan which has been implementing a target for long-term bond yields since 2016 based on flexible asset purchases, labelled 'yield curve control'.

stronger economic activity in the originator economy might result in increased business confidence in the recipient country and/or higher inflation in the recipient country. Anticipating stronger growth and/or inflationary pressure in the recipient country, market participants will update their expectation that the local central bank will soon also hike interest rates. This macroeconomic linkages channel will result in comovement of short-term interest rate. Yet, as there is also an information (or expectations) element at play—in that interest rates in the recipient country can respond to expectations of future interest rate moves—also medium-term interest rates of the recipient country are likely to comove with those in the originator economy through this channel.

(b) FX regime. Spillovers can occur via a foreign exchange (FX) channel if a country pegs its exchange rate to that of another (typically larger) economy. Such a peg could either be formal, with a fixed exchange rate, or informal, for example where the recipient country's exchange rate is notionally floating but in practice the central bank intervenes to avoid large exchange rate movements, a situation referred to as a managed or 'dirty' float. If the country pegging its exchange rate has an open capital account then its interest rates will need to move with those of the larger economy in order to avoid substantial, destabilising capital flows towards the economy with the higher interest rate that would result in (undesired) large exchange rate movements (see, e.g. Shambaugh, 2004).

If interest rates in the originator economy change then those in the recipient economy will similarly have to adjust. Even if the central bank in the recipient economy does not alter its policy rate immediately, markets will expect its policy rate to adjust and so the yield curve of the recipient country will quickly move in line with that in the originator economy. In essence, the country pegging its exchange rate 'outsources' its monetary policy to the originator economy. Not only will this lead to a co-movement in short-term rates, but if the peg is credible and expected to persist, medium- and longer-term interest rates will also co-move.[5]

[5]Even some countries with notionally flexible exchange rate regimes may want to avoid large exchange rate adjustments against a major currency, e.g. for trade competitiveness or financial stability reasons, and hence their policy rates may tend to shadow that of the originator economy. Equivalently, if the central bank in the recipient country intervenes in the FX market to smooth the bilateral exchange rate, then even if such interventions are sterilized, its local bond yields will tend to mirror those of the originator economy through signaling and/or portfolio re-balancing effects.

(c) Financial links. With globally integrated financial markets, movements in bond risk premia (in particular, term premium components) in a large economy can drive those in other economies. Such a comovement in bond risk premia can occur, for instance, through the portfolio flows of international investors that are active in different countries' bond markets as they seek higher yielding assets, often described as a 'search for yield'.[6] Spillover effects can also arise due to the presence of global intermediaries and their relevant risk constraints (see, e.g. Bruno and Shin (2015) and Malamud and Schrimpf (2018)). Because spillovers through this financial linkages channel reflect portfolio re-balancing and flows by international investors as risk premia change, one would expect this channel to manifest itself mostly via a response of the long end of the yield curve.

The importance of spillovers through the financial links channel will depend on the degree of financial integration between the economies. This channel, in particular if it operates independently of the exchange rate regime, also relates to the ongoing debate on the global financial cycle and the 'dilemma not trilemma' conjecture of Rey (2013) and Rey (2016). We return to this issue when we discuss the implications of our results.

2.2 Related literature

This paper relates to several branches of the literature. Various papers examine how foreign asset prices respond to monetary policy surprises, although nearly all only consider interest rate changes by the largest central banks, the U.S. Federal Reserve and/or the European Central Bank (ECB). Extant work typically only considers a relatively narrow set of recipient countries (often emerging markets).[7] A number of papers have documented interest rate spillovers to foreign bonds, notably Andersen, Bollerslev, Diebold, and Vega (2007) and Gilchrist, Yue, and Zakrajšek (2019).[8] While most papers consider spillovers at the long-end of the yield curve, there is less work on spillovers at the short-end and the evidence is more mixed. Takáts and Vela (2014) and Edwards (2015) find evidence of spillovers to short-term or policy rates, but many other papers, e.g. Devereux and Yetman (2010), Miyajima,

[6] This channel also relates to the risk-taking channel of monetary policy, as coined by Adrian and Shin (2010) and Borio and Zhu (2012). Bekaert, Hoerova, and Duca (2013) find that US monetary policy (measured via changes in policy rates) affects variance risk premiums based on the VIX, a common gauge for the global price of risk.

[7] Some papers also look at the spillovers to exchange rates or foreign equities, such as Kim and Nguyen (2009), Wongswan (2006), Wongswan (2009), Ammer, Vega, and Wongswan (2010), and Brusa, Savor, and Wilson (2020).

[8] Other earlier contributions include Ehrmann and Fratzscher (2003), Forbes and Chinn (2004), Faust, Rogers, Wang, and Wright (2007), Craine and Martin (2008) and Ehrmann and Fratzscher (2009) for equity markets.

Mohanty, and Yetman (2014), and Obstfeld (2015) do not.[9] Others have looked at interest rate spillovers in a broader context, noting there are net economic spillovers, for example Fukuda, Kimura, Sudo, and Ugai (2013), Ammer, De Pooter, Erceg, and Kamin (2016) and Georgiadis (2016).

Our paper is also related to the recent literature on the international impact of QE. Many papers have found spillovers from the Federal Reserve asset purchases, including Neely (2011), Wright (2012), Bauer and Neely (2014), Fratzscher, Lo Duca, and Straub (2017) and Rogers, Scotti, and Wright (2018).[10] In comparison with conventional monetary policies, Curcuru, Kamin, Li, and Rodriguez (2018) found that QE did not exert greater international spillovers. Other studies have also found that other major central banks' QE policies also triggered spillovers; Rogers, Scotti, and Wright (2014) and Chen, Filardo, He, and Zhu (2016) show that Fed, Bank of England and ECB unconventional policies affected foreign bond yields, although QE by the Bank of Japan did not. In contrast, Fratzscher, Duca, and Straub (2016) conclude that unconventional policies by the ECB had negligible effects on other countries' yields.

Some papers have gone beyond documenting international interest rate spillovers, and attempt to explain them. Two papers have a similar objective to ours. Hausman and Wongswan (2011) look at the effect of FOMC announcement surprises on short and long interest rates (for 20 countries). They use a fairly small number of explanatory variables to model the cross-section of responses, though, and study a sample period that ends before the global financial crisis. Bowman, Londono, and Sapriza (2015) examine what variables relate to the strength of (only) U.S. unconventional monetary policy (UMP) spillovers to emerging market sovereign yields. They do not consider spillovers to advanced economies, though, and only focus on the effects of QE. A number of other papers have found the importance of spillovers to relate to various specific factors, including Shah (2017) (the level of interest rates), Aizenman, Chinn, and Ito (2016) and MacDonald (2017) (degree of integration), Mishra, Moriyama, N'Diaye, and Nguyen (2014) and Ahmed, Coulibaly, and Zlate (2017) (economic fundamentals for emerging market economies), Jotikasthira, Le, and Lundblad (2015) (risk compensation) and Ehr-

[9] While most papers typically use daily (and sometimes intra-data), some others have looked at spillovers to foreign interest rates, or other asset prices, with lower frequency VARs combining monthly or quarterly macro data. In some cases, these papers impose a Taylor rule to attempt to separate common shocks from spillovers, which makes strong assumptions about the suitability of the Taylor rule for identification of spillovers, see for example Bredin, Hyde, and Reilly (2010), Fukuda, Kimura, Sudo, and Ugai (2013), Hofmann and Takáts (2015), Dedola, Rivolta, and Stracca (2017), and Han and Wei (2018).

[10] This literature builds on studies finding that QE compressed domestic long-term yields, for the United States see Gagnon, Raskin, Remache, Sack, et al. (2011), Krishnamurthy and Vissing-Jorgensen (2011) and Swanson (2017) and also Christensen and Rudebusch (2012) for the U.S. and U.K., and Krishnamurthy, Nagel, and Vissing-Jorgensen (2018) for the ECB.

mann and Fratzscher (2005) (monetary union).[11]

Our paper improves upon this existing work by precisely identifying interest rate spillovers from a broader set of central banks (the four major central banks), not just the Federal Reserve, for both short- and long-term interest rates. A key feature of our work is to consider the *full matrix of spillovers* to a broad set of 47 advanced and emerging market economies. This approach is sensible given the dense network structure of financial claims connecting different economies highlighted in Shin (2017). Crucially, we then put some structure on the transmission of spillovers by using a comprehensive dataset covering bilateral and aggregate economic and financial links. The goal of these empirical tests is to assess through which channels interest rate spillovers occur.

3 Research design: detecting and explaining spillovers

This section provides a brief summary of the main features of the research design. Our empirical analysis of spillovers proceeds in two stages.

Detecting spillovers. First, we test which central banks' policy actions trigger spillovers to others, and which countries' interest rates are most receptive. Specifically, we start with separate regressions for each originator-recipient combination of economies to compare spillovers from shock-originating central banks to recipient economies' interest rates. The equation we estimate is

$$\Delta r_{i,t} = \alpha_{ij} + \beta'_{ij}\text{MPS}_{j,t} + \varepsilon_{i,j,t}, \tag{1}$$

where $\Delta r_{i,t}$ is the interest rate change in the recipient country i and $\text{MPS}_{j,t}$ is our measure of monetary policy surprises in the originator economy j. We provide details on measurement in Section 4 below.

Explaining spillovers. Second, we aim to distinguish between the different spillover channels outlined above by drawing on the richness of our data in the cross-section of countries. The three channels differ in the types of macro and financial conditions affecting the strengths of spillovers across coun-

[11] Other studies have examined how the spillovers to equities and exchange rates in emerging markets relate to economic fundamentals, such as Aizenman, Binici, and Hutchison (2016).

tries. For the macroeconomic links channel, we expect that spillovers should positively relate to bilateral trade flows as well as real interlinkages more generally (that would result in synchronized business cycles and inflation across countries). The FX regime channel posits that, when an exchange rate is tied to that of a major currency, volatility in the corresponding exchange rate cross will be dampened. Hence, one would expect FX volatility and spillover strength to be negatively correlated. As for the financial links channel, a key prediction is that countries that are more financially open should receive larger spillovers.

To shed light on the empirical relevance of the three channels as spillover determinants, we run the following panel regression with interaction terms

$$\Delta r_{i,t} = \alpha_j + \theta_j' Z_t + \left(\beta_j' + \gamma_j' X_{i,t-1}\right) \mathrm{MPS}_{j,t} + \varepsilon_{i,j,t}, \tag{2}$$

where Z_t is a global control; $X_{i,t}$ is a recipient-specific conditioning variable; θ_j measures the sensitivity to global controls; β_j is a vector that measures the unconditional spillover from our three monetary policy surprises.[12] Our main object of interest here is the coefficient on the interaction term, γ_j, which measures the spillover *conditional* on (recipient) country-specific controls.

Our conditioning variables $X_{i,t}$ either measure macroeconomic or financial links between the originator and recipient countries' economies or the FX regime of the recipient country. Another important dimension to differentiate the channels is the maturity of the interest rates that will be affected relatively more by spillovers. The macroeconomic links channel will be more prevalent for short- to medium-term interest rates because it affects current and expected policy rate settings. The FX regime channel will operate predominantly via short-term interest rates, even though longer-term rates might also be affected to some extent. As for the financial links channel, we expect mostly long-term rates to be subject to spillover effects. This is because yields at the longer end of the yield curve are more susceptible to risk premium fluctuations and portfolio rebalancing by international investors than yields at the shorter end. Table 1 summarizes the different predictions of the three spillover channels and our empirical approach to differentiate among them.

Insert Table 1 about here

[12] For conditional variables, some of them measure bilateral relations. In that case, they are not only recipient-specific but also originator-specific.

4 Data

A key feature of our work is to rely on high-frequency data on various interest rates to measure the surprise element of monetary policy announcements. This approach ensures exogeneity of the measured monetary policy surprises, and hence allows us to pin down the direction of spillovers in a causal sense. As outlined in detail below, we use a long sample of intraday interest rate data to identify monetary policy surprises and examine how they spill over. For the identification of originator-recipient specific spillovers (Equation (1)) we use a common sample period from April 2004 to June 2019, while to identify the channels of spillovers (Equation (2)) we extend the sample as much as possible, since we are not estimating recipient country-specific parameters, by using an unbalanced panel from March 1999 to June 2019.

High-frequency monetary policy surprises. We construct monetary policy surprises from interest rate changes in a narrow window around monetary policy announcements. Our sample of events includes the release of the outcome of policy meetings (both scheduled and any unscheduled meetings) and, when there is one, the press conference that follows the policy meeting. We summarize the monetary policy surprise from country j at time t by a three-dimensional vector to capture the different components of news included in the central bank announcement

$$\text{MPS}_{j,t} = \begin{bmatrix} \tilde{\Delta} r_{j,t}^{3\text{m}} \\ \tilde{\Delta} r_{j,t}^{2\text{y}} - \tilde{\Delta} r_{j,t}^{3\text{m}} \\ \tilde{\Delta} r_{j,t}^{10\text{y}} - \tilde{\Delta} r_{j,t}^{2\text{y}} \end{bmatrix}, \tag{3}$$

where $\tilde{\Delta} r$ represents the change in the interest rate in a narrow window around the event.

For policy announcements, the window is from 15 minutes before, to 15 minutes after, the announcement. For press conferences, the window is from 15 minutes before the announcement time, to 90 minutes after. We use the 30 minute (or 105 minute for press conferences) window to account for the time the market takes to process the news. We use intraday data for the most liquid instruments for each currency to calculate the monetary policy surprises, as listed in Table IA.1 in the Online Appendix. Depending on the liquidity and availability by country, we use a mix of OIS and futures rates

for 3-month interest rates, and cash and bond futures for the 2-year and 10-year yields.[13] The source of our high-frequency data is Thomson Reuters TickHistory.

The first component of the monetary policy surprise vector given in Equation (3) is the change in the 3-month interest rate. We refer to this as the 'target' surprise as it captures the repricing of market expectations of the short-term policy rate target. The second component is the change in the 2-year rate minus the change in 3-month rate. We refer to this as the 'path' surprise, as it largely reflects revisions in investor expectations of the expected path of policy rates in the near future. These two components originally proposed by Gürkaynak, Sack, and Swanson (2005) have been commonly used in the literature.

To broaden the channels through which monetary policy can have an impact, and to accommodate episodes of unconventional policies, we expand the monetary policy surprise vector by a third component—a 'long rate' surprise. We measure this surprise as the change in the 10-year rate minus the change in the 2-year rate. This component is intended to capture the response of risk premia to news about unconventional monetary policy, in particular the impact of asset purchase programs which have been found to operate to a large extent via their impact on long rates. Gilchrist, Yue, and Zakrajšek (2019) adopted a similar measure to asses the impact of U.S. unconventional monetary policy.[14]

Database of monetary policy events. Our analysis draws on an extensive database of monetary policy events. We consider four advanced economy central banks as spillover originators: the Federal Reserve, the European Central Bank, the Bank of Japan, and the Bank of England.[15] The database of monetary policy events for the construction of monetary policy surprises for these central banks is an expanded version of the one used in Cieslak and Schrimpf (2019).

Insert Table 2 about here

[13] OIS contracts are OTC derivatives contracts allowing investors to hedge against (or speculate on) movements the average level of the overnight rate over the maturity of the contract. Unlike futures which refer to the overnight rate in a particular calendar month, the maturity in the OIS contract is fixed. OIS contracts are widely traded in a broad array of currencies. Where futures are more liquid than cash instruments we use those.

[14] Also see Swanson (2017) for an approach that is similar in spirit to ours.

[15] We also considered surprises from three smaller economies with liquid financial markets, Switzerland, Canada and Australia but as they do not have significant spillovers they are not included here, see the working paper version of this paper (Kearns, Schrimpf, and Xia (2018)).

An overview of the different central banks' monetary policy events is given in Table 2. The sample covers a pre-GFC period from 1999 or the early 2000s (depending on availability of the high-frequency data for the currency area). It runs through to mid-2019, giving 120–262 events for each central bank. For the initial analysis, we use a common sample period for all countries to ensure comparability; this runs from 9 April 2004 to 19 June 2019.

Insert Table 3 about here

Table 3 presents summary statistics for the monetary policy surprises. It shows that while the means of the surprises are small as one would expect, their standard deviation is sizeable (especially for path and long rate surprises). This indicates that the sample period contains a broad range of positive and negative observation for different types of surprises. The large degree of variability in the policy surprises aids identification.

Our long sample covers different phases of monetary policy for these central banks. For example, for the Fed, with expectations building for the subsequent tightening, in early 2004 path surprises were large, while in the 2007–2009 financial crisis there were very large (positive and negative) target, path and long-rate surprises. These large surprises can be attributed to significant changes in expectations at the time and the large amount of easing that the Fed implemented, which frequently caught market participants by surprise. Moreover, target surprises were close to zero for six years after 2009 as the Fed funds rate was constrained by the effective lower bound (ELB). With forward guidance firmly anchoring expectations, the subsequent policy tightening was very well telegraphed resulting in very small target surprises, while path surprises remained somewhat more volatile as market participants responded to changes in the Fed's forward guidance and the evolving macroeconomic outlook.

Gauging spillovers to recipient countries. We use a broad panel of 27 advanced and 20 emerging market economies as recipients of potential spillovers. The wide cross-section delivers power to shed light on the different channels outlined above.[16] Each recipient country's interest rate change is computed as the daily change from the closing yields preceding the monetary policy announcement to

[16]Table IA.2 in the Online Appendix presents an overview of the recipient countries in our sample.

the subsequent daily closing yield (which will be after the policy announcement). These changes are calculated with careful adjustment of time-zone difference and daylight saving time conventions. For long-term interest rates, we use 10-year sovereign bond yields, and for short-term interest rates we use the most representative 1-month or 3-month rate for each country. Our daily interest rate data are taken from Bloomberg (definitions and codes are given in Online Appendix Table IA.3).

Note that, while the three monetary policy surprise variables are constructed from the *high-frequency* data to precisely pin down monetary policy surprises, we opt for measuring the interest rates of the recipient countries with *daily* data for two reasons: first, it allows us to use a much broader panel of countries (including EMEs), and second it consistently mitigates issues due to any time-zone difference, which mean that many markets are closed (or less active) when our four originator central banks unveil their policy decisions.

Conditioning variables. To test our three channels that can drive spillovers we use a broad range of macro and financial variables to explain cross-country differences in the strength of spillovers. Our tests of the macroeconomic links channel rely on bilateral imports and exports.[17] We also constructed measures of growth and inflation correlations from realized GDP and CPI to capture a broad range of economic interlinkages across countries that would result in common cycles. To gauge the FX regime channel, we compute a measure of realized FX volatility from squared daily changes of spot exchange rates (see, e.g. De Grauwe and Schnabl, 2008, for a similar approach to construct de facto measures of FX regimes). To asses the financial links channel, we rely on a range of proxies of financial openness. We consider both the overall financial openness of recipient countries and the bilateral financial openness between recipient countries and originator countries. We make use of a wide range of data to gauge financial openness, including bilateral holdings of portfolio equity and debt, bilateral and aggregate FDI, as well as the currency composition of debt. Details on variable definitions and sources are provided in Table IA.4 in the Online Appendix.

[17] The regressions also control for variables commonly used in the trade literature explaining the volume of trade between countries, such as geographical distance and common language. For the sake of brevity, we do not report the coefficients.

5 Does monetary policy spill over to other countries?

We start with Equation (1) to test whether monetary policy surprises originating from the four major central banks spill over to the recipient countries under consideration. To measure the interest rate response, we present results for short-maturity and long-maturity (10-year) interest rates.[18] We define that a spillover from an originator central bank j to a recipient country i is significant if the p-value from the F-test of joint significance of $\widehat{\beta}_{ij}$ for the three monetary policy surprises coefficients is less than 10%. Estimation is over the common sample, ranging from April 2004 to June 2019.

Insert Figure 1 about here

Figure 1 shows the share of countries whose interest rates respond significantly to the policy surprises originating from our four major advanced economy central banks, with the two panels showing short-term and long-term rates. Given the large number of recipient countries, to simplify the exposition, we show the strength of spillovers to recipient countries grouped by world regions and split into advanced economies and EMEs.

Spillovers to short-term interest rates. A first key finding is that there are few meaningful spillovers to interest rates at the short-end of the yield curve (Panel (a) of Figure 1). While a small number of advanced economies experience statistically significant responses of short-term interest rates to monetary policy surprises from the main advanced central banks, hardly any EMEs experience significant spillovers.[19]

Spillovers to long-term interest rates. We generally find spillovers to be much more prevalent at the long-end of the yield curve. Over three-quarters of advanced economies show statistically significant responses of 10-year yields to Fed and ECB policy surprises. Spillovers by ECB monetary policy surprises to long-term interest rates are fairly strong, but for the most part, concentrated in advanced economies. When it comes to spillovers to EMEs, the Fed stands out as the most powerful spillover

[18] In the Online Appendix, we present results for two intermediate interest rates, 6-month and 2-year (Figure (IA.5))

[19] As shown in the Online Appendix (Figure (IA.5)), the spillover patterns are broadly similar to 6-month interest rates, but with a larger share of advanced economy interest rates responding to Fed surprises.

originator. The Fed even seems to have a more pronounced impact on the long-term rates of European emerging markets than the ECB does.

Spillovers by the other major central banks are less pronounced, and unlike the Fed and ECB are not felt at a global level. Virtually no advanced economies respond to surprises by the Bank of Japan, but some EMEs (notably in Asia) do. The Bank of England does not consistently generate spillovers to either advanced economy or emerging market long-term bond yields.

While the share of advanced economies receiving statistically significant Fed and ECB spillovers is greater than that of EMEs, it is also important to inspect the economic magnitude of those spillovers. To inspect this further, Figure 2 plots the median (and interquartile range) coefficients for spillovers to 10-year bond yields for advanced economies and EMEs. This analysis shows that—despite more muted statistical significance—spillovers due to target and path surprises from the Fed generate economically sizable positive spillovers to EMEs. This finding in turn suggests that unexpected shifts in the course of US monetary policy seem to be especially important for some emerging market economies' interest rates.

The analysis also reveals the striking pattern that—in contrast to conventional wisdom—spillovers from long-end surprises are generally larger for advanced economies than EMEs. This is striking given the announcement of QE involved large unexpected movements in long-term interest rates, and it has often been asserted that emerging markets suffered particularly from spillovers due to QE.[20] We return to this point later. In the case of the ECB, we find that all types of monetary policy surprises tend to generate larger spillovers for advanced economies than emerging markets.

Insert Figure 2 about here

The geography of spillovers. While it is generally accepted that the Fed generates spillovers around the world, Figures 3 and 4, show that the ECB also has geographically dispersed spillovers. These figures visualize the geographic intensity of spillovers by the Fed and the ECB as the R^2 of the individual country spillover regressions in Equation (1) and depicted by varying the shading in the graph.

[20] For an example, see the Governor of the Reserve Bank of India (Rajan, 2016).

Not surprisingly most countries in Europe and in Asia have significant responses to Fed announcements as well as some in South America, Africa and the Middle East. But what is surprising is the geographic spread of countries that experience spillovers from ECB monetary policy. While the ECB spillovers are widespread, they tend to be less intense than those of the Fed outside of Europe.[21] A potential reason for the outsized global role of the Fed and smaller spillovers from the other central banks could be the relative role of the respective currencies in trade invoicing, as argued by Zhang (2018).

Insert Figure 3 about here

Insert Figure 4 about here

Is the importance of spillovers evolving over time? The past two decades have seen vast changes in central banking and economic and financial linkages between countries and so the importance of interest spillovers may have evolved over time. Figure 5 depicts variation in the importance of Fed and ECB spillovers over time, based on a rolling regression (with a window of 60 monetary policy events). The measure of spillover importance is the R^2 of the rolling regression that captures how well the daily movement in recipients' interest rates can be explained by the originators' monetary policy surprises. We depict both the median and the 25% and 75% quantiles of the individual R^2s, shown separately for different sets of countries.

Insert Figure 5 about here

The graph shows that the overall importance of spillovers originating the Fed has been broadly unchanged—even during the period of unconventional monetary policy. We see a slight pickup only in the response of emerging markets and advanced economies outside of the Euro-area.

ECB monetary policy surprises, by contrast, have shown more notable variation over time. The right panel of Figure 5 shows that ECB spillover importance picked up during our sample, especially for advanced economies as recipients. There was also a significant change in the way that individual

[21] In the Online Appendix, we also show spillover maps for the Bank of Japan and Bank of England, see Figures IA.6 and IA.7). These graphs corroborate the limited global impact of spillovers originating from these two central banks, in contrast to the Fed and the ECB.

Euro-area country yields responded to ECB monetary policy surprises. With the onset of the Euro-area debt crisis in 2010, peripheral Euro-area countries had a much weaker response to ECB surprises, while the manner in which core Euro-area countries responded did not change. The extent to which ECB surprises transmitted to Euro-area countries' yield movements thus differed markedly in this period (Figure 5 and Figure IA.8 in the Online Appendix).[22] This evidence is consistent with a breakdown of policy transmission within the Euro-area. However, then with assertive action by the ECB to contain the debt crisis, from about 2015 (time of the launch of the public sector purchase program - PSPP) the response of peripheral Euro-area countries' yields began to mimic that of the core countries again. Indeed, in recent years the transmission mechanism had been functioning strongly with ECB policy announcements having a large effect on all Euro-area countries' bond yields.

Panel regressions. We now move away from our originator-recipient specific regressions and adopt a panel regression specification (given by Equation (2)) in order to understand the main drivers of spillovers to long-term rates. We look at the response in 10-year yields here as the previous originator-recipient regressions had highlighted that there are much larger spillovers at the long end of the yield curve. The panel regressions are run for surprises from the Fed and ECB as these spillovers are stronger and more widespread, and from this point forward we drop the BoE and BoJ from the remaining analysis.[23] Because we combine all recipient countries in a single panel for each of the Fed and ECB, we use the maximum available time span of data in an unbalanced panel (reflecting data availability for each recipient country). The sample is 2003 to mid-2019 for the Fed surprises, and 1999 to mid-2019 for the ECB surprises. The panel regression restricts the unconditional spillover strength (the coefficients on the target, path, and long-rate surprises) to be the same across countries, but in a conditional sense they will vary based on the characteristics of the recipient country.

The baseline panel regression results only using monetary policy surprises as regressors are shown in the top half of each panel in Table 4. The estimated coefficients and panel-corrected standard errors corroborate the existence of strong monetary spillover effects from both the Fed and ECB. The coeffi-

[22] Individual country results in the Online Appendix Figure IA.8 demonstrate this distinction between core and peripheral Euro-area countries.

[23] Note that (unreported) panel regressions confirm the earlier single-country results that that there are significant spillovers from the Fed and ECB, but not the BoJ or BoE. Results are available by the authors upon request.

cients on all three monetary policy surprises are significant for both of these central banks.

Insert Table 4 about here

To confirm that these results are not driven by other factors that drive yields in both originator and recipient countries, we add to the regression two variables to control for global factors influencing yields – the *daily* change in 10-year U.S. Treasury yields and the VIX.[24] Both variables are significant for the Fed and ECB regressions. Yet, even after controlling for these global factors, all of the monetary policy surprises remain significant, with the magnitudes unchanged in the Fed regression but slightly reduced in the ECB regression. This panel specification including the two global variables serves as our baseline regression for the remainder of the paper.

The spillovers we identify are not only statistically, but also economically significant. Our baseline results (Table 4, specification with global controls) indicate that a 10 basis point 'target' surprise from the Fed (on average) translates into around a 8 basis points change in 10-year government bond yields globally. For both path and long-rate surprises, a 10 basis point surprise translates into roughly 5 basis point spillovers, or about one half of the original interest rate shock. The pass-through is smaller for ECB surprises, with a 10 basis point surprise resulting in approximately 3 basis point spillovers for each of the three surprises.

Spillover effects for different periods and types of monetary policy surprises. In light of the previous evidence that the importance of spillovers is evolving over time, we now assess to what extent spillover strength differs depending on the type of monetary policy news, how the policy change is implemented or what is communicated. To this end, we first interact the monetary policy surprises with a state dependent dummy variable to consider whether the spillover effects are different for: (i) unconventional monetary policy (UMP); (ii) policy announcements containing forward guidance (FG); (iii) monetary policy tightening vs. easing; and (iv) the post-GFC period vs pre-crisis.[25] Results are reported in Table 5.

[24]The daily change in the 10-year US Treasury yield controls for any spillovers to global yields outside of our event window. For regressions with the surprises originating from the Fed, the daily change is orthogonalized relative to the measured monetary policy surprises to avoid collinearity.

[25]The classification of events according to whether they contain news about unconventional monetary policy and forward guidance draws on the database in Cieslak and Schrimpf (2019).

Insert Table 5 about here

We find that spillovers from both the ECB and Fed for unconventional policy and forward guidance announcements are not significantly different from those generated by regular monetary policy related announcements. The key coefficients in Panels A and B of Table 5 are those on the interaction terms of the three types of monetary policy surprises with a dummy for UMP or FG events. None of these coefficients are even close to being statistically significant, indicating that the global spillover impact is not materially different for these innovations in the central banks' toolbox.

Similarly, we find that spillovers do not differ significantly for tightening vs easing surprises (Panel C Table 5). Here the dummy used for the interaction takes the value of one if the monetary policy surprise is positive, i.e. if the announcement leads to a surprise monetary tightening. For the ECB, there is some evidence that tightening target surprises lead to a weaker spillover than easing surprises, but this is not the case for the other two types of monetary policy surprises. For the Fed, there is no evidence that tightening or easing surprises would have different impacts. We also find that the intensity of spillovers does not materially differ before and after the GFC (Panel D of Table 5).

The second way we examine the impact of different types of monetary policy surprises is by considering the type of news conveyed by the central bank announcement. Does pure monetary news have a different spillover impact than news about the state of the economy revealed through the central bank announcement, or news affecting risk premia? To answer this question, we use the approach of Cieslak and Schrimpf (2019) – which looks at the covariance of stock and bond yield at central bank announcements along different maturities of the yield curve – to decompose our monetary policy surprises into pure 'monetary news', news about economic 'growth', and shocks to 'risk' appetite.[26]

Based on this classification at hand, we assess how interest rates in other countries respond to Fed and ECB monetary policy depending on which of the three types of news is dominant in the policy

[26]The method by Cieslak and Schrimpf (2019) exploits high-frequency comovement of stocks and interest rates along different maturities of the yield curve. As the classification is only available to us for the sample until December 2017, we use a slightly shorter sample compared to the baseline in this exercise. Table IA.5 in the Online Appendix provides a summary of the number and frequency of the events where the dominant driver of the market reaction is news about monetary policy, economic growth, or news affecting risk premia. For the Fed, in the majority of the cases Fed monetary policy was the dominant piece of information driving the market reaction. For the ECB, there is a more even split between economic growth and monetary policy news. For both central banks, news affecting risk premia occur less frequently as dominant driver of the market reaction (<10% of cases).

announcement. Specifically, we run the following regression

$$\Delta r_{i,t} = \alpha_j + \theta_j' Z_t + (\gamma_{j,growth}' \iota_{j,t}^{growth} + \gamma_{j,risk}' \iota_{j,t}^{risk} + \gamma_{j,MP}' \iota_{j,t}^{MP}) MPS_{j,t} + \varepsilon_{i,j,t}.$$

Our main interest lies in the interaction coeffients $\hat{\gamma}_j$s which measure the spillover impact separately for the different types of news. Results are reported in Table 6 and indicate a dominant role of pure monetary news in generating spillover effects to other countries' interest rates.

For both central banks, announcements that are classified as predominantly containing information about monetary policy (and so the monetary news dummy variable is equal to one) have significant spillovers through all three surprise measures. Growth news, however, tends to have a somewhat more muted spillover impact when gauged by statistical significance and the magnitude of the impact (with the response of emerging markets to Fed target and path surprises as an exception). Growth news conveyed via central bank announcements largely transmits via target and path surprises, which makes sense as these are the two surprises that reflect the changes to the near-term and future setting of monetary policy in the originator countries. In contrast, for news affecting risk premia, the long-rate surprise stands out as the most dominant for both central banks. Statistical significance is weaker for announcements associated with news about risk premia, but in some instances estimated coefficients are quite large. Notably this is the case for emerging markets' response to Fed risk shocks, which in turn may be due to the strong reaction of EME asset prices during the so-called taper tantrum episode.

Insert Table 6 about here

6 What determines the strength of spillovers?

Having identified that there are significant spillovers to bond yields in a broad range of countries, we now move to investigate the main economic drivers behind these spillovers. Specifically, we aim to shed light on the different channels by examining which macro and financial variables determine the strength of spillover effects under the specification of Equation (2). The empirical results are reported in Tables 7 - 10. Our interpretation of the results presented below adheres to the framework of the three channels outlined above.

Macroeconomic links channel. To test the macroeconomic links channel, we interact monetary policy surprises with measures of economic links between countries. The main prediction of the macroeconomic links channel is that countries with tighter economic links with spillover-originator economies should receive stronger spillovers. We first use trade variables to capture the direct economic links between countries. The trade-related variables we use are bilateral export openness (exports from the recipient country to the originator country relative to GDP), and bilateral import openness. In the regressions we include (but do not report for brevity) control variables typically used in the trade gravity equation literature: common language, weighted distance and time difference.

Insert Table 7 about here

The results are presented in Table 7. There is empirical support for macroeconomic links channel in determining spillover strength for ECB surprises to advanced economies, but it vanishes once Euro-area countries are excluded (the coefficients not only lose significance but most change sign). There is weaker evidence that trade links of the United States with other countries explain the importance of those countries' response to monetary policy surprises from the Fed. There is also no sign that stronger macroeconomic links influence the significance of spillovers for EMEs, with most coefficients being insignificant (with the exception being significant negative coefficients—suggesting that stronger trade links lead to smaller interest rate spillovers).

However, trade is only a small portion of the economic links between countries which also include the actions of multi-national companies, information and investment flows and common global demand shocks. Hence, we also consider broader measures of economic links across countries: long-term realized correlations in real GDP growth and inflation, agnostic as to what drives the correlation. Results using these measures as interaction terms are also presented in Table 7.[27] The positive and significant coefficients on inflation and growth correlation interacted with Fed and ECB surprises for advanced economies indicate that those countries more integrated with the United States and Euro-area receive stronger bond yield spillovers. However, again the interaction coefficients lose their significance when the Euro-area countries are excluded as the recipient of the spillover for ECB surprises. Again in

[27] We estimate the commonality in countries' business cycle and inflation with a 20-year rolling regressions. The results are robust to sensible variations of this setup.

contrast, for EMEs most coefficients are not significant and those that are significant are negative. Overall, these results indicate that stronger economic links tend to result in larger spillovers for advanced econmies, but not for emerging market economies.

FX regime channel. To test the FX regime channel in our panel regression framework, we interact monetary policy shocks with a measure to capture the FX regime. The channel predicts that countries 'pegging' their currencies to those of the surprise originator should experience stronger spillovers. Rather than rely on 'de jure' (stated) measures of FX regimes, we construct a 'de facto' (effective) measure as in De Grauwe and Schnabl (2008), which essentially boils down to the realized bilateral exchange rate volatility between the originator and recipient economies.

Table 8 about here

The results reported in Table 8 provide some evidence in support of the FX regime channel for interest rate spillovers. Advanced economies with *lower* bilateral exchange rate volatility with the originator economy, i.e. due to an explicit or implicit currency peg, see *higher* interest rate spillovers (all three interactive coefficients are negative for both the Fed and ECB, and two are statistically significant for the ECB and one for the Fed). While results for advanced economies are in line with the predictions of the FX regime channel, for emerging market economies, the results are less consistent. For ECB spillovers to EMEs, the coefficients are again negative and similar size in magnitude, but for the Fed, the coefficients are *positive* and statistically significant, but very small in magnitude. EMEs whose currency moves closely with the US dollar, and so have lower bilateral US dollar exchange rate volatility, actually have slightly smaller interest rate spillovers from the Fed. Overall, these results suggest that spillover strengths are related to FX regimes for advanced economies, in line with recent findings in Han and Wei (2018), but not consistently so for EMEs.

Financial links channel. To assess the validity of the financial links channel, we interact monetary policy surprises with measures of financial openness. The main idea is that the more financially open and interconnected an economy, the more will risk premia embedded in its government bond yields fluctuate in lock-step with global factors. We rely on a broad set of bilateral financial openness and flow

measures, such as the recipient country's foreign currency debt (i.e. denominated in the currency of the originator country, either in US dollars or euros), and portfolio debt and equity (again bilateral flows between the originator and recipient countries, including assets and liabilities separately) expressed as a share of GDP. We present robustness results based on a broad range of other measures of financial openness in the Online Appendix including other aggregate measures of openness.[28]

Insert Table 9 about here

Results of our investigation of the financial links channels are reported in Table 9. The results are especially strong for the ECB; coefficients on the interaction terms with our openness measures are almost always positive and significant. For the Fed, the path and long-rate surprises are positive and significant for portfolio debt in US dollar, as is the path surprise for foreign currency debt. However, other financial openness proxies are not significant for the Fed.[29]

Comparing the channels. To test the relative importance of the three channels, we further run a joint regression including the best performing variable for each channel. We include growth correlation (for the macroeconomic channel), portfolio debt from the originator country (for the financial link channel) and FX volatility (FX regime channel). The joint test of the three channels reported in Table 10 corroborates the prior interpretation that the financial links channel is the dominant one to explain spillovers to advanced economies. For EMEs, the results are inconclusive. For advanced economies, macroeconomic links are no longer significant when variables for the other channels are included. Only one of the variables for the FX regime channel is significant (the path variable in the ECB excluding Euro-area). In contrast, there is strongest evidence for the financial links channel.

Overall, our finding on the importance of financial openness in explaining spillovers is consistent with Rey (2013). It points to important spillovers of major central banks' monetary policies to other

[28] In robustness tests, we use further aggregate measures of financial openness: including debt assets, portfolio assets, FDI assets and financial derivative assets (and separately, the equivalent liability measures) as well as the Chinn-Ito measure of financial openness. Table IA.6 in the Online Appendix presents results with alternative measures of financial openness. Ideally, we would like to have each country's fixed income holdings in different currencies as a financial openness measure given its important role in portfolio choices of global fixed income investors. Unfortunately, such granular data does not exist for all countries we considered.

[29] It is possible that recipient countries experiencing strong spillovers may take measures tightening financial openness to tame spillovers. This would result in negative relation between spillover strength and financial openness. The potential downward bias would actually make our evidence supporting financial linkages channel stronger.

countries' long-term rates and hence an impact on local financial conditions, regardless of whether the capital account is managed or not. What is notable though is that our findings suggest that such reduced independence of the central bank when it comes to control over local financial conditions, is most prevalent for advanced economies given their already fairly deep levels of financial integration.

Insert Table 10 about here

These results in favour of the financial links channel for advanced economies are consistent with the earlier evidence that spillovers are more prevalent for for longer maturity rates. For example for the Fed, only 30% of countries experience significant spillovers to short rates, but this rises a little to 39% to 6 months interest rates, to 69% to 2-year bond yields, and to 78% to 10-year yields. ECB spillovers follow a similarly monotonic pattern along the term structure of interest rates, with similar numbers (25%, 41%, 59%, 72%). As noted in Table 1, this increasing spillover by interest rate maturity is evidence in favour of the financial links channel.

7 Conclusion

While it is fairly well established that there is co-movement of interest rates across countries, less is known about the economic and financial forces behind this co-movement. Using precisely identified monetary policy surprises for four major central banks, we provide new stylised facts on the nature of interest rate spillovers to 47 advanced and emerging market economies. The use of high frequency data is important as it enables us to identify spillovers in a causal sense. We robustly demonstrate that there are clear spillovers of monetary policy surprises by the Fed, and even the ECB, to other countries' long-term bond yields. However, in contrast to some earlier papers using more restricted samples, we show that their monetary policies do not consistently spill over to other countries' short-term interest rates. We also show that spillovers from other major central banks, including the Bank of Japan and Bank of England, are mild at most. Further, in contrast to much of the literature which has emphasized spillovers to emerging market economies, we show that the spillovers are actually more important to advanced economies.

To put some structure on why these spillovers occur and why some countries are more prone to

receive spillovers than others we test three possible channels. We study the role of macroeconomic links, FX regime and financial links. Using a rich set of bilateral and aggregate economic and financial data, we find that there is only mild evidence that interest rate spillovers relate to macroeconomic links across countries or the FX regime. Instead, the financial links channel emerges as the strongest determinant of interest rate spillovers. The channel is especially powerful for advanced economies that are well financially integrated with the US and Euro-area economies. Countries that have stronger bilateral (and aggregate) financial links with the US or Euro-area are susceptible to stronger interest rate spillovers. These effects are also much more pronounced at the longer end of the yield curve. While weaker, the evidence for the FX regime channel suggests that countries that have more flexible exchange rates may experience fewer spillovers, and so exchange rate flexibility could be a mechanism to dampen interest rate spillovers.

Our results indicate that domestic financial conditions—as a consequence of increased financial openness— will move more closely with those in the two major currency areas. While there are benefits to financial openness, a cost it seems is less independence of domestic financial conditions. In particular, this tradeoff will be an important extension to incorporate in theoretical open economy models in order to assess the constrained optimal policy consideration that has trade-offs between the costs and benefits of international financial integration, exchange rate volatility and independence of financial conditions.

References

ADRIAN, T., AND H. S. SHIN (2010): "Financial intermediaries and monetary economics," in *Handbook of Monetary Economics*, ed. by B. M. Friedman, and M. Woodford. 1 edn., vol. 3, chap. 12, pp. 601–650.

AHMED, S., B. COULIBALY, AND A. ZLATE (2017): "International financial spillovers to emerging market economies: How important are economic fundamentals?," *Journal of International Money and Finance*, 76, 133–152.

AIZENMAN, J., M. BINICI, AND M. M. HUTCHISON (2016): "The transmission of Federal Reserve tapering news to emerging financial markets," *International Journal of Central Banking*, 12(2), 317–356.

AIZENMAN, J., M. D. CHINN, AND H. ITO (2016): "Monetary policy spillovers and the trilemma in the new normal: Periphery country sensitivity to core country conditions," *Journal of International Money and Finance*, 68, 298–330.

AMMER, J., M. DE POOTER, C. ERCEG, AND S. KAMIN (2016): "International spillovers of monetary policy," in *Board of Governors of the Federal Reserve System, IFPD Notes, February 8*.

AMMER, J., C. VEGA, AND J. WONGSWAN (2010): "International transmission of US monetary policy shocks: Evidence from stock prices," *Journal of Money, Credit and Banking*, 42(s1), 179–198.

ANDERSEN, T. G., T. BOLLERSLEV, F. X. DIEBOLD, AND C. VEGA (2007): "Real-time price discovery in global stock, bond and foreign exchange markets," *Journal of International Economics*, 73(2), 251–277.

BAUER, M. D., AND C. J. NEELY (2014): "International channels of the Fed's unconventional monetary policy," *Journal of International Money and Finance*, 44, 24–46.

BAXTER, M., AND M. A. KOUPARITSAS (2005): "Determinants of business cycle comovement: a robust analysis," *Journal of Monetary Economics*, 52(1), 113–157.

BEKAERT, G., M. HOEROVA, AND M. L. DUCA (2013): "Risk, uncertainty and monetary policy," *Journal of Monetary Economics*, 60(7), 771–788.

BORIO, C., AND H. ZHU (2012): "Capital regulation, risk-taking and monetary policy: a missing link in the transmission mechanism?," *Journal of Financial Stability*, 8(4), 236–251.

BOWMAN, D., J. M. LONDONO, AND H. SAPRIZA (2015): "US unconventional monetary policy and transmission to emerging market economies," *Journal of International Money and Finance*, 55, 27–59.

BREDIN, D., S. HYDE, AND G. O. REILLY (2010): "Monetary policy surprises and international bond markets," *Journal of International Money and Finance*, 29(6), 988–1002.

BRUNO, V., AND H. S. SHIN (2015): "Capital flows and the risk-taking channel of monetary policy," *Journal of Monetary Economics*, 71, 119–132.

BRUSA, F., P. SAVOR, AND M. WILSON (2020): "One central bank to rule them all," *Review of Finance*, 24(2), 263–304.

CAMPBELL, J. R., C. L. EVANS, J. D. FISHER, AND A. JUSTINIANO (2012): "Macroeconomic effects of Federal Reserve forward guidance," *Brookings Papers on Economic Activity*, 2012(1), 1–80.

CERUTTI, E., S. CLAESSENS, AND A. K. ROSE (2019): "How important is the global financial cycle? Evidence from capital flows," *IMF Economic Review*, 67(1), 24–60.

CHEN, Q., A. J. FILARDO, D. HE, AND F. ZHU (2016): "International spillovers of central bank balance sheet policies," *Journal of International Money and Finance*, 67, 62–81.

CHRISTENSEN, J. H., AND G. D. RUDEBUSCH (2012): "The response of interest rates to US and UK quantitative easing," *The Economic Journal*, 122(564), F385–F414.

CICCARELLI, M., AND B. MOJON (2010): "Global inflation," *The Review of Economics and Statistics*, 92(3), 524–535.

CIESLAK, A., AND A. SCHRIMPF (2019): "Non-monetary news in central bank communication," *Journal of International Economics*, 118, 293–315.

CRAINE, R., AND V. L. MARTIN (2008): "International monetary policy surprise spillovers," *Journal of International Economics*, 75(1), 180–196.

CURCURU, S. E., S. B. KAMIN, C. LI, AND M. RODRIGUEZ (2018): "International spillovers of monetary policy: Conventional policy vs. quantitative easing," *FRB International Finance Discussion Paper*, (1234).

DAHLQUIST, M., AND H. HASSELTOFT (2013): "International bond risk premia," *Journal of International Economics*, 90(1), 17–32.

DE GRAUWE, P., AND G. SCHNABL (2008): "Exchange rate regimes and macroeconomic stability in Central and Eastern Europe," *Review of Development Economics*, 12, 530–549.

DEDOLA, L., G. RIVOLTA, AND L. STRACCA (2017): "If the Fed sneezes, who catches a cold?," *Journal of International Economics*, 108, S23–S41.

DEVEREUX, M. B., AND J. YETMAN (2010): "Leverage constraints and the international transmission of shocks," *Journal of Money, Credit and Banking*, 42(s1), 71–105.

DIEBOLD, F. X., M. PIAZZESI, AND G. D. RUDEBUSCH (2005): "Modeling bond yields in finance and macroeconomics," *American Economic Review*, 95(2), 415–420.

EDWARDS, S. (2015): "Monetary policy independence under flexible exchange rates: an illusion?," *The World Economy*, 38(5), 773–787.

EHRMANN, M., AND M. FRATZSCHER (2003): "Monetary policy announcements and money markets: A transatlantic perspective," *International Finance*, 6(3), 309–328.

——— (2005): "Equal size, equal role? Interest rate interdependence between the euro area and the United States," *The Economic Journal*, 115(506), 928–948.

——— (2009): "Global financial transmission of monetary policy shocks," *Oxford Bulletin of Economics and Statistics*, 71(6), 739–759.

FAUST, J., J. H. ROGERS, S.-Y. B. WANG, AND J. H. WRIGHT (2007): "The high-frequency response of exchange rates and interest rates to macroeconomic announcements," *Journal of Monetary Economics*, 54(4), 1051–1068.

FORBES, K. J., AND M. D. CHINN (2004): "A decomposition of global linkages in financial markets over time," *Review of Economics and Statistics*, 86(3), 705–722.

FRATZSCHER, M., M. L. DUCA, AND R. STRAUB (2016): "ECB unconventional monetary policy: Market impact and international spillovers," *IMF Economic Review*, 64(1), 36–74.

FRATZSCHER, M., M. LO DUCA, AND R. STRAUB (2017): "On the international spillovers of US quantitative easing," *The Economic Journal*, 128, 330–377.

FUKUDA, Y., Y. KIMURA, N. SUDO, AND H. UGAI (2013): "Cross-country transmission effect of the US monetary shock under global integration," Discussion paper, Bank of Japan.

GAGNON, J., M. RASKIN, J. REMACHE, B. SACK, ET AL. (2011): "The financial market effects of the Federal Reserve's large-scale asset purchases," *International Journal of Central Banking*, 7(1), 3–43.

GEORGIADIS, G. (2016): "Determinants of global spillovers from US monetary policy," *Journal of International Money and Finance*, 67, 41–61.

GILCHRIST, S., V. YUE, AND E. ZAKRAJŠEK (2019): "US monetary policy and international bond markets," *Journal of Money, Credit and Banking*, 51, 127–161.

GÜRKAYNAK, R. S., B. SACK, AND E. T. SWANSON (2005): "Do actions speak louder than words? The response of asset prices to monetary policy actions and statements," *International Journal of Central Banking*, pp. 55–93.

GÜRKAYNAK, R. S., AND J. H. WRIGHT (2012): "Macroeconomics and the term structure," *Journal of Economic Literature*, 50(2), 331–67.

HAN, X., AND S.-J. WEI (2018): "International transmissions of monetary shocks: Between a trilemma and a dilemma," *Journal of International Economics*, 110, 205–219.

HAUSMAN, J., AND J. WONGSWAN (2011): "Global asset prices and FOMC announcements," *Journal of International Money and Finance*, 30(3), 547–571.

HOFMANN, B., AND E. TAKÁTS (2015): "International monetary spillovers," *BIS Quarterly Review*

September, pp. 105–128.

JOTIKASTHIRA, C., A. LE, AND C. LUNDBLAD (2015): "Why do term structures in different currencies co-move?," *Journal of Financial Economics*, 115(1), 58–83.

KEARNS, J., A. SCHRIMPF, AND F. D. XIA (2018): "Explaining monetary spillovers: The matrix reloaded," .

KIM, S.-J., AND D. Q. T. NGUYEN (2009): "The spillover effects of target interest rate news from the US Fed and the European Central Bank on the Asia-Pacific stock markets," *Journal of International Financial Markets, Institutions and Money*, 19(3), 415–431.

KOSE, M. A., C. OTROK, AND C. H. WHITEMAN (2003): "International business cycles: World, region, and country-specific factors," *The American Economic Review*, 93(4), 1216–1239.

KRISHNAMURTHY, A., S. NAGEL, AND A. VISSING-JORGENSEN (2018): "ECB policies involving government bond purchases: Impact and channels," *Review of Finance*, 22(1), 1–44.

KRISHNAMURTHY, A., AND A. VISSING-JORGENSEN (2011): "The effects of quantitative easing on interest rates: channels and implications for policy," *Brookings Papers on Economic Activity*, (2).

MACDONALD, M. (2017): "International capital market frictions and spillovers from quantitative easing," *Journal of International Money and Finance*, 70, 135–156.

MALAMUD, S., AND A. SCHRIMPF (2018): "An intermediation-based model of exchange rates," *CEPR Discussion Paper No. DP13182*.

MIRANDA-AGRIPPINO, S., AND H. REY (2015): "World asset markets and the global financial cycle," *CEPR Discussion Paper No. DP10936*.

MISHRA, P., K. MORIYAMA, P. M. N'DIAYE, AND L. NGUYEN (2014): *Impact of Fed tapering announcements on emerging markets*, no. 14-109. International Monetary Fund.

MIYAJIMA, K., M. S. MOHANTY, AND J. YETMAN (2014): "Spillovers of US unconventional monetary policy to Asia: the role of long-term interest rates," BIS working paper No. 478.

NAKAMURA, E., AND J. STEINSSON (2018): "High-frequency identification of monetary non-neutrality: the information effect," *The Quarterly Journal of Economics*, 133(3), 1283–1330.

NEELY, C. J. (2011): *The large-scale asset purchases had large international effects*. Federal Reserve Bank of St. Louis, Research Division.

NEELY, C. J., AND D. E. RAPACH (2011): "International comovements in inflation rates and country characteristics," *Journal of International Money and Finance*, 30(7), 1471–1490.

OBSTFELD, M. (2015): "Trilemmas and trade-offs: living with financial globalisation," *BIS Working Paper 480*.

RAJAN, R. (2016): "Towards rules of the monetary game," Talk by Dr Raghuram Rajan, Governor of the Reserve Bank of India, at the IMF/Government of India conference on "Advancing Asia: Investing for the Future", New Delhi, 12 March 2016.

REY, H. (2013): "Dilemma not trilemma: the global cycle and monetary policy independence," in *Proceedings-Economic Policy Symposium-Jackson Hole*, pp. 285–333. Federal Reserve Bank of Kansas City.

REY, H. (2016): "International channels of transmission of monetary policy and the Mundellian trilemma," *IMF Economic Review*, 64(1), 6–35.

ROGERS, J. H., C. SCOTTI, AND J. H. WRIGHT (2014): "Evaluating asset-market effects of unconventional monetary policy: a multi-country review," *Economic Policy*, 29(80), 749–799.

——— (2018): "Unconventional monetary policy and international risk premia," *Journal of Money, Credit and Banking*, 50(8), 1827–1850.

SHAH, N. (2017): "Monetary spillovers in financial markets: policymakers and premia," Working Paper, Harvard University.

SHAMBAUGH, J. C. (2004): "The effect of fixed exchange rates on monetary policy," *The Quarterly Journal of Economics*, 119(1), 301–352.

SHIN, H. S. (2017): "Accounting for global liquidity: reloading the matrix," Speech at the IMF-IBRN Joint Conference, Washington DC.

SWANSON, E. T. (2017): "Measuring the effects of Federal Reserve forward guidance and asset purchases on financial markets," Discussion paper, National Bureau of Economic Research.

TAKÁTS, E., AND A. VELA (2014): "International monetary policy transmission," *BIS Paper*, (78b).

WONGSWAN, J. (2006): "Transmission of information across international equity markets," *Review of Financial Studies*, 19(4), 1157–1189.

——— (2009): "The response of global equity indexes to US monetary policy announcements," *Journal of International Money and Finance*, 28(2), 344–365.

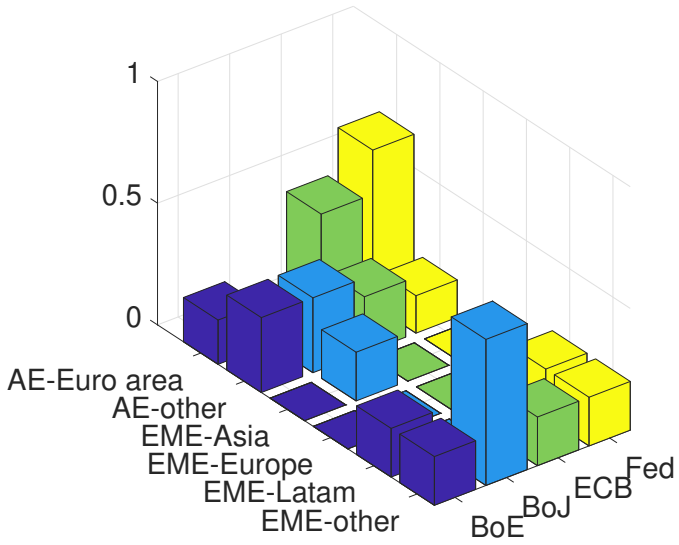
WRIGHT, J. H. (2012): "What does monetary policy do to long-term interest rates at the zero lower bound?," *The Economic Journal*, 122(564), F447–F466.

ZHANG, T. (2018): "Monetary policy spillovers through invoicing currencies," Working paper, University of Chicago.

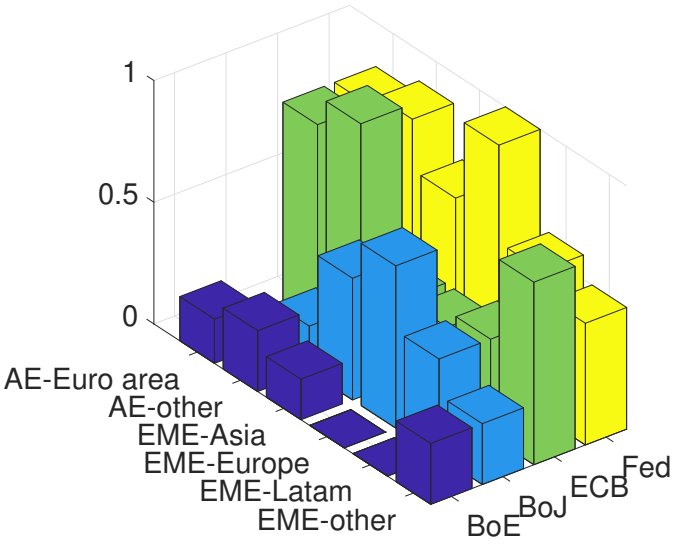
Figures and Tables

Figure 1: Global Spillover Matrix for Short-term and Long-term Interest Rates

(a) Short-term rates



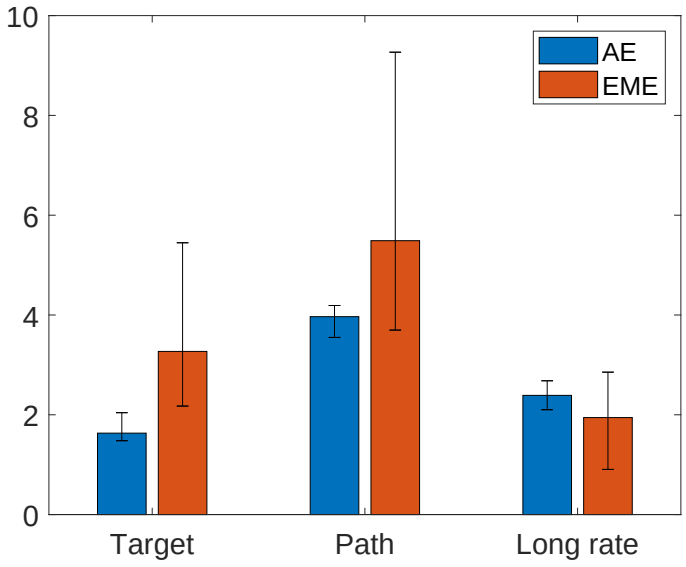
(b) Long-term rates



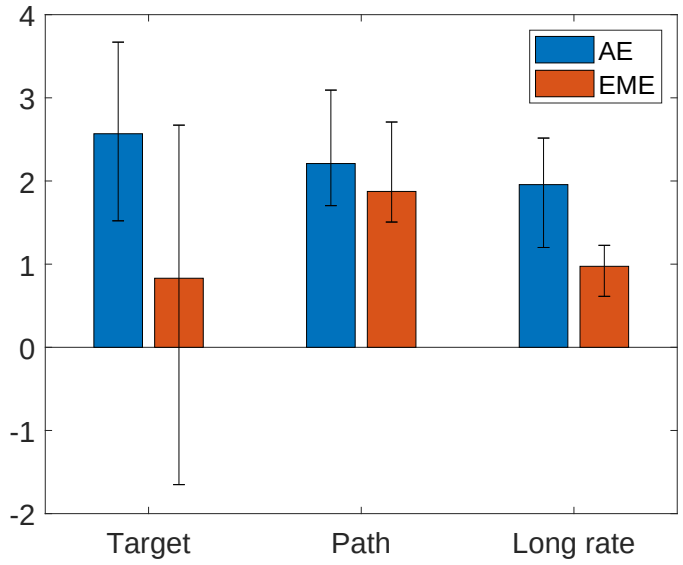
Notes: The figure plots the fraction of countries in each world region receiving a significant spillover from monetary policy surprises originating from four major central banks. It provides a compact summary of regression results of Equation (1) for 47 recipient countries. The originator central banks are the Federal Reserve Bank (Fed), European Central Bank (ECB), Bank of Japan (BoJ) and Bank of England (BoE). The data sample spans from April 2004 and June 2019, when monetary policy surprises are available for all the four central banks. Panel (a) refers to spillovers to short-term rates (1-month or 3-month); Panel (b) refers to long-term rates (10-year bond yield), respectively. A spillover is counted as significant if the p-value from the F-test of joint significance of $\widehat{\beta}_{ij}$ coefficients in Equation (1) is less than 10%.

Figure 2: Global Spillover Intensity to Long-term Interest Rates

(a) Federal Reserve

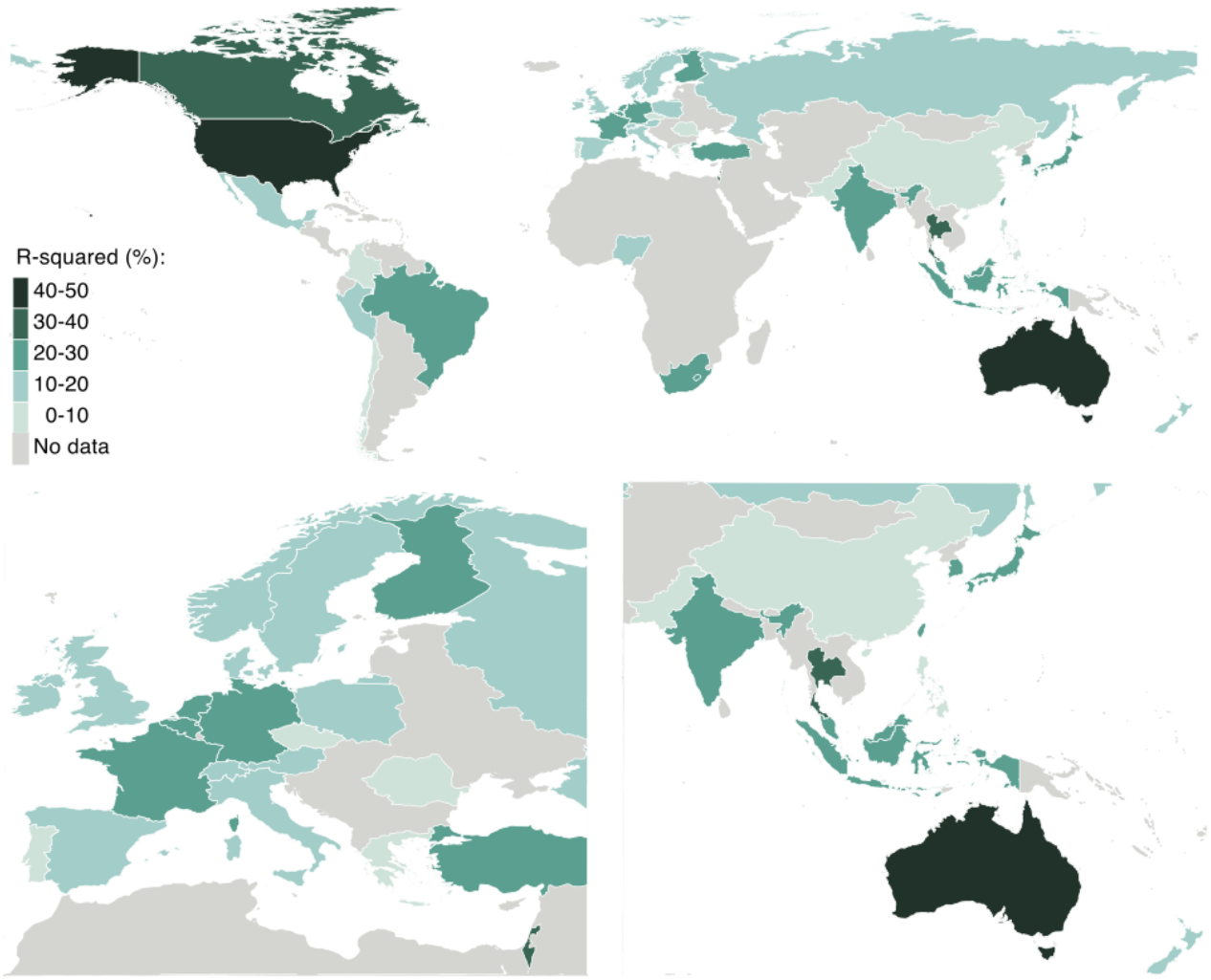


(b) ECB



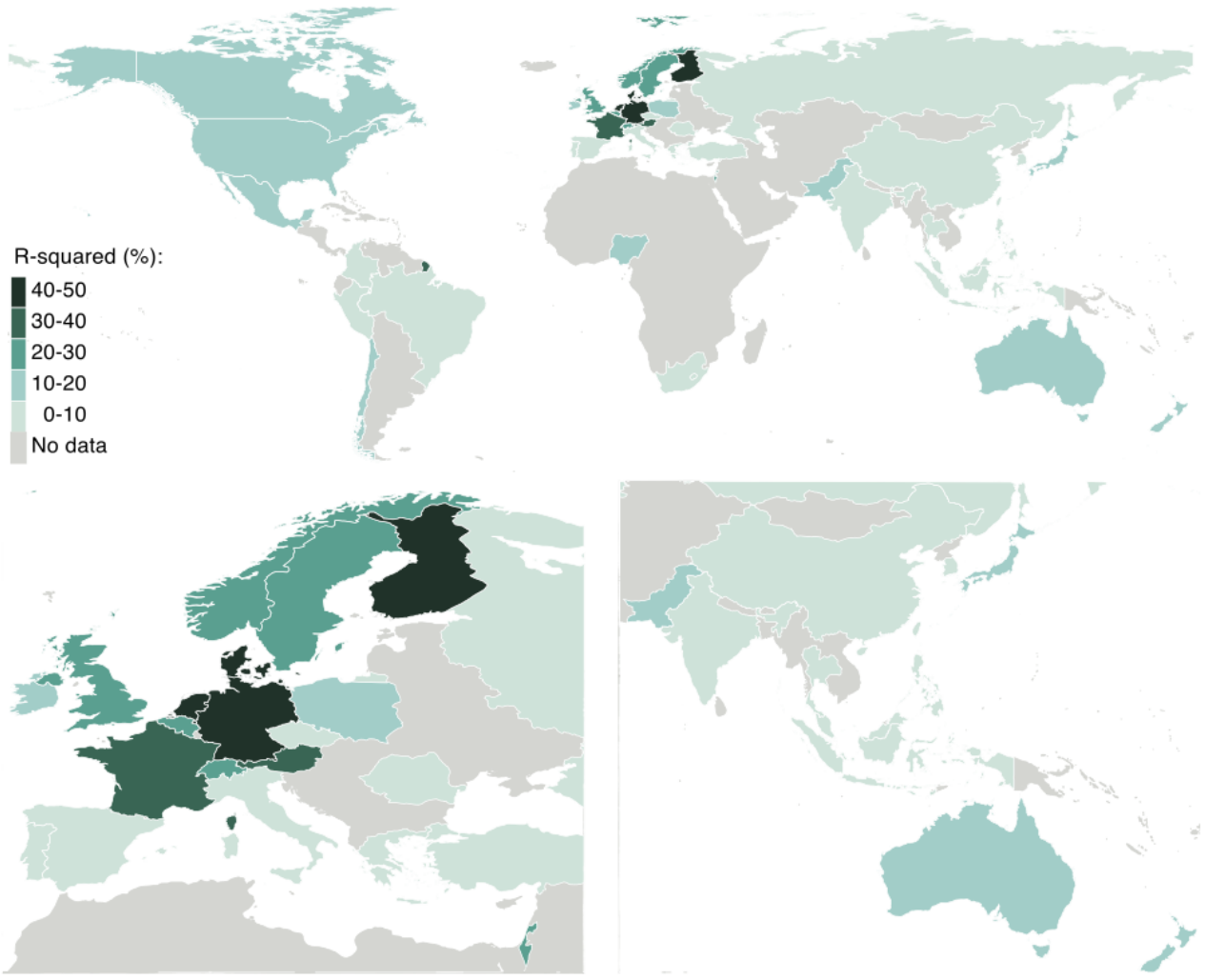
Notes: The figure plots the median and 25% to 75% interquartile range of the spillover coefficient $\widehat{\beta}_{ij}$, obtained from estimating the originator-recipient regressions from Equation (1). Results are separately shown for advanced economies and emerging market economies that receive significant spillover from surprises generated by the Fed and ECB. A spillover is counted as significant if the p-value from the F-test of joint significance of $\widehat{\beta}_{ij}$ coefficients in Equation (1) is less than 10%.

Figure 3: Global Map of Fed Spillovers



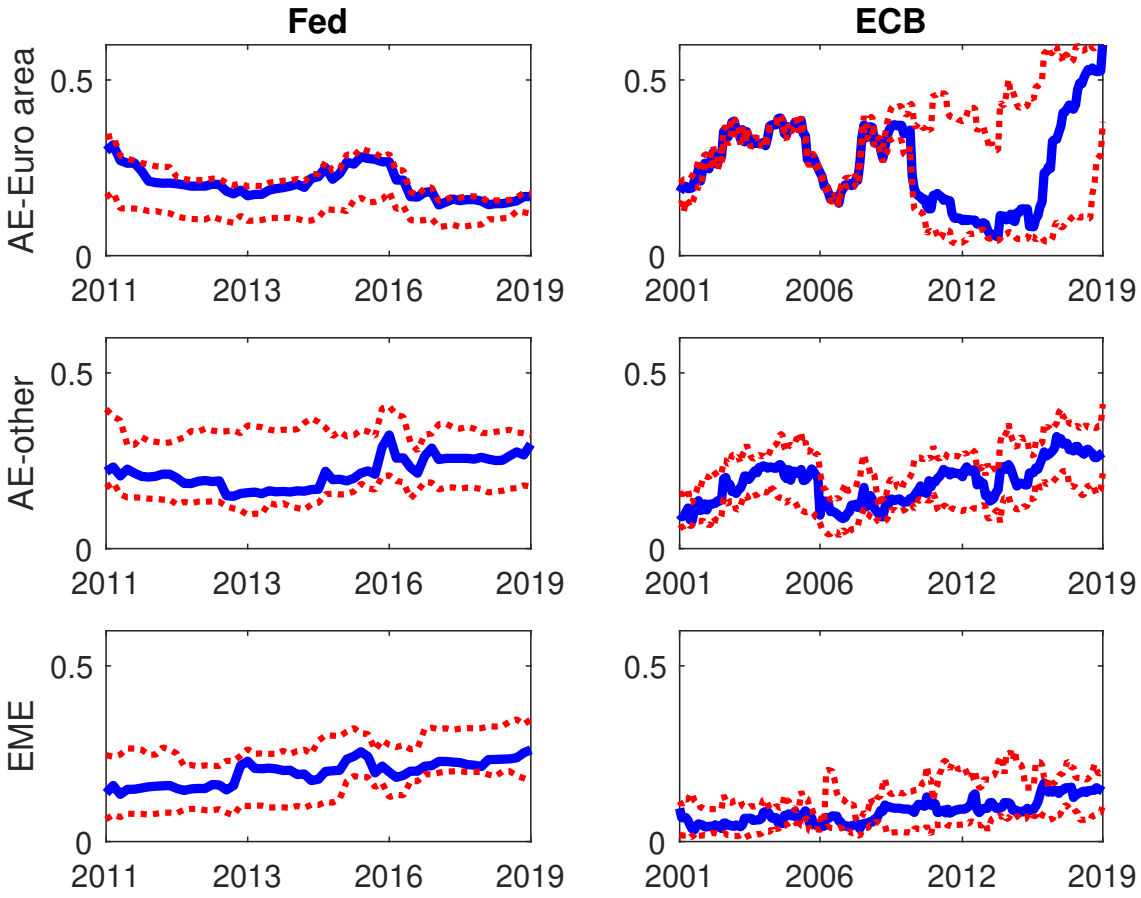
Notes: The figure provides a global map that depicts the importance of monetary policy spillovers generated by the Federal Reserve to 10-year bond yields of 47 recipient countries around the globe. Spillover importance is measured based on the R^2 of the regression of the individual countries' 10-year bond yields on the three Fed monetary policy surprises (following Equation (1)). The sample period spans from April 2004 to June 2019.

Figure 4: Global Map of ECB Spillovers



Notes: The figure provides a global map that shows the importance of monetary policy spillovers generated by the ECB to 10-year bond yields of 47 recipient countries around the globe. Spillover importance is measured based on the R^2 of the regression of the individual countries' 10-year bond yields on the three ECB monetary policy surprises (following Equation (1)). The sample period spans from April 2004 to June 2019.

Figure 5: Time-variation in Spillover Importance



Notes: The figure shows how the importance of monetary policy spillovers originating from the Fed and the ECB varies over time based on rolling window regressions. Specifically, we estimate the originator-recipient regression of Equation (1) for the 47 countries on a rolling basis with 60 observations. Spillover importance is measured via the R^2 capturing how well the daily response in long-term interest rates in the recipient countries can be explained by the three monetary policy surprises for the Fed and ECB. The graph then shows median and 25% to 75% interquartile range of the R^2 from the rolling spillover regression.

Table 1: Distinguishing Spillover Channels

	Channel	Maturity of Affected Interest Rates	Macro-financial Conditioning Variables
(a)	Macroeconomic Links	Short to medium	Trade (+); Commonality in Growth and Inflation (+)
(b)	FX Regime	Both Short and Long	FX Volatility (–)
(c)	Financial Links	Long	Financial Openness (+)

Notes: The table summarizes testable implications of the three spillover channels along two key dimensions: (i) maturity of the affected interest rates, and (ii) macroeconomic or financial conditioning variables determining whether spillovers might be stronger or weaker. The (+)/(–) sign in parentheses indicates whether the expected relationship between the conditioning variables and spillover strength is positive or negative.

Table 2: Summary Statistics of Monetary Policy Events

	Start	End	# Total	# MPD	# MPD+PC
Fed	2003-12-09	2019-06-19	120	87	33
ECB	1999-03-04	2019-06-06	262	42	220
BoJ	2004-04-09	2019-04-25	185	135	50
BoE	2004-04-08	2019-05-02	172	159	13

Notes: The table provides an overview of the available sample period of monetary policy events for the four originator central banks used in this study. It also reports the total number of monetary policy events and how these are split up between monetary policy decision announcements ('MPD') and instances where the monetary policy decision also comes along with a press conference ('MPD+PC') to provide background to the decision.

Table 3: Summary Statistics of Monetary Policy Surprises

	Mean (bps)			**Std. (bps)**		
	Target	Path	Long-rate	Target	Path	Long-rate
Fed	-0.38	0.40	-0.13	2.65	6.92	5.86
ECB	-0.06	0.13	-0.16	3.97	3.86	3.36
BoJ	-0.02	0.03	-0.01	0.86	0.79	1.05
BoE	0.28	0.20	-0.40	4.50	6.79	5.85

Notes: The table summarizes basic statistics for our three monetary policy surprise measures for each of the four spillover originator central banks. The monetary policy surprise measures (Target, Path and Long-rate) are constructed following Equation (3) and as described in the text. The table shows mean and standard deviation for the three surprises (measured in basis points).

Table 4: Panel Spillover Regressions

	Target	Path	Long-rate	10y UST	VIX	R^2
Panel A. All countries						
Fed	0.76	0.58	0.45			6%
	(5.22)	(8.36)	(6.41)			
ECB	0.47	0.54	0.42			2%
	(5.82)	(7.76)	(4.19)			
Fed	0.82	0.53	0.44	0.27	0.16	8%
	(6.29)	(8.47)	(6.93)	(5.57)	(3.53)	
ECB	0.34	0.35	0.25	0.24	0.07	3%
	(4.31)	(5.02)	(2.49)	(7.95)	(2.46)	
Panel B. Advanced economies						
Fed	0.63	0.52	0.46			11%
	(4.29)	(7.53)	(6.31)			
ECB	0.59	0.66	0.53			8%
	(8.03)	(10.19)	(6.28)			
Fed	0.65	0.50	0.45	0.25	0.08	15%
	(4.84)	(7.70)	(6.76)	(5.00)	(1.66)	
ECB	0.40	0.42	0.31	0.31	0.05	14%
	(6.37)	(7.21)	(4.20)	(10.81)	(2.04)	
Panel C. Emerging market economies						
Fed	1.06	0.72	0.40			4%
	(4.61)	(6.38)	(3.72)			
ECB	0.22	0.28	0.22			0%
	(1.25)	(1.97)	(1.01)			
Fed	1.21	0.60	0.38	0.32	0.34	6%
	(5.80)	(5.98)	(3.89)	(3.99)	(4.25)	
ECB	0.23	0.25	0.18	0.03	0.11	0%
	(1.28)	(1.57)	(0.79)	(0.46)	(1.62)	

Notes: The table reports the results of panel regressions as given by Equation (2) to assess the impact of monetary policy spillovers originating from the Fed and the ECB. These results in turn serve as baseline specification for the remainder of our analysis. The dependent variable is the daily change in 10-year bond yields in our set of 47 recipient countries. In Panel A, the sample covers all recipient countries, while in Panel B and C, separate results are reported when the sample is restricted to advanced economies and emerging market economies, respectively. As regressors, besides the monetary surprises for the ECB and the Fed, some specifications also consider the daily change in the US Treasury yield and the VIX as global controls. The reported coefficients correspond to $\hat{\beta}_j$ and $\hat{\theta}_j$ in Equation (2). t-statistics based on Panel-Corrected Standard Errors (PCSE) are given in parentheses. Cells coloured red (green) indicate statistically significant positive (negative) coefficients at a 10% confidence level.

Table 5: State-dependence of Spillovers

	Target	**Path**	**Long-rate**	**Target** $\times \iota$	**Path** $\times \iota$	**Long-rate** $\times \iota$	**10y UST**	**VIX**	R^2
Panel A.					$\times$ UMP Dummy				
Fed	0.82	0.54	0.49	-0.25	0.17	-0.14	0.26	0.14	8%
	(5.60)	(6.19)	(4.73)	(-0.38)	(0.91)	(-1.02)	(5.20)	(3.00)	
ECB	0.35	0.37	0.31	0.05	0.01	-0.14	0.24	0.08	3%
	(3.95)	(4.58)	(2.56)	(0.18)	(0.04)	(-0.65)	(7.96)	(2.65)	
Panel B.					$\times$ FG Dummy				
Fed	0.86	0.59	0.54	1.66	-0.17	-0.14	0.29	0.17	8%
	(6.25)	(7.54)	(5.99)	(1.27)	(-0.75)	(-0.87)	(5.73)	(3.47)	
ECB	0.33	0.35	0.26	0.09	-0.37	-0.71	0.24	0.07	3%
	(4.28)	(5.05)	(2.55)	(0.04)	(-0.29)	(-0.33)	(8.03)	(2.44)	
Panel C.					$\times$ Tightening surprise Dummy				
Fed	0.82	0.39	0.52	0.17	0.21	-0.35	0.28	0.15	8%
	(5.44)	(3.00)	(6.74)	(0.44)	(1.26)	(-1.64)	(5.72)	(3.24)	
ECB	0.53	0.34	0.12	-0.39	0.10	0.26	0.24	0.09	3%
	(5.19)	(3.44)	(0.95)	(-2.93)	(0.69)	(1.47)	(7.90)	(2.99)	
Panel D.					$\times$ Post-GFC Dummy				
Fed	0.72	0.49	0.51	0.06	0.24	-0.20	0.27	0.13	8%
	(4.32)	(4.66)	(4.19)	(0.16)	(1.64)	(-1.35)	(5.68)	(2.91)	
ECB	0.32	0.34	0.22	0.01	0.02	0.03	0.24	0.07	3%
	(3.18)	(3.75)	(1.68)	(0.07)	(0.18)	(0.17)	(7.98)	(2.45)	

Notes: The table presents results for an augmented panel regression where interaction terms are added to gauge the state dependence of spillovers. Specifically, we analyse if spillover effects are different for (i) unconventional vs conventional monetary policies, (ii) forward guidance, (iii) tightening vs easing surprises, (iv) post-crisis vs pre-crisis. Specifically, we run the following panel regression: $\Delta r_{i,t} = \alpha_j + \theta_j' Z_t + (\beta_j' + \gamma_j' \iota_{j,t}) MPS_{j,t} + \varepsilon_{i,j,t}$ where the dummy variable $\iota_{j,t}$ takes value 1 if $MPS_{j,t}$ is classified as event containing news about unconventional monetary policy (UMP), or news about forward guidance (FG); is positive (element-wise) consistent with a surprise policy tightening; occurs after 2009; respectively. The first set of coefficients relate to the three monetary policy surprises (i.e. $\hat{\beta}_j$), while those reported in the next three columns measure the interaction effects (i.e. $\hat{\gamma}_j$). The last two columns report coefficients on the global controls. t-statistics based on Panel-Corrected Standard Errors (PCSE) are given in parentheses. Cells coloured red (green) indicate statistically significant positive (negative) coefficients at a 10% confidence level. The data sample spans from April 2004 and June 2019.

Table 6: Types of Monetary Policy Surprises and Spillovers

	Target	Path	Long-rate	Target	Path	Long-rate	Target	Path	Long-rate	10y	VIX	R^2
	× *Growth news*			× *Risk*			× *Monetary news*			UST		
Panel A. All countries												
Fed	0.85	0.58	0.41	1.32	1.15	1.42	0.95	0.47	0.43	0.28	0.16	13%
	(3.80)	(3.46)	(1.43)	(0.64)	(0.91)	(2.37)	(3.77)	(6.96)	(6.76)	(5.65)	(3.32)	
ECB	0.19	0.29	0.06	0.42	-0.10	0.36	0.40	0.43	0.35	0.23	0.06	4%
	(1.64)	(2.96)	(0.41)	(1.16)	(-0.29)	(1.50)	(3.54)	(4.17)	(2.38)	(8.13)	(1.95)	
Panel B. Advanced economies												
Fed	0.64	0.52	0.40	2.01	0.37	1.94	1.00	0.46	0.44	0.26	0.10	16%
	(2.66)	(2.86)	(1.29)	(0.93)	(0.28)	(3.07)	(3.72)	(6.39)	(6.28)	(5.03)	(2.08)	
ECB	0.32	0.31	0.19	0.74	0.13	0.43	0.51	0.56	0.47	0.30	0.03	14%
	(3.05)	(3.57)	(1.65)	(2.79)	(0.44)	(2.38)	(5.34)	(6.32)	(3.91)	(10.04)	(1.20)	
Panel C. Emerging market economies												
Fed	1.31	0.65	0.32	0.50	3.02	0.47	0.83	0.50	0.42	0.31	0.27	13%
	(4.55)	(3.08)	(0.89)	(0.18)	(1.73)	(0.59)	(2.40)	(5.31)	(4.77)	(4.72)	(4.19)	
ECB	-0.08	0.29	-0.17	-0.44	-0.68	0.25	0.22	0.16	0.17	0.05	0.10	1%
	(-0.30)	(1.42)	(-0.59)	(-0.44)	(-0.71)	(0.46)	(0.91)	(0.75)	(0.54)	(0.83)	(1.68)	

Notes: This table differentiates the impact of spillovers based on whether the dominant driver of the financial market reaction is news (i) about economic growth ('Growth news'), (ii) news affecting risk premia ('Risk'), or (iii) news about monetary policy ('Monetary news'). The classification of announcements is based on Cieslak and Schrimpf (2019) (also see Table IA.5 in the Online Appendix), and given limited data availability, the sample ends 2017. To gauge the differential impact of the types of news, our monetary policy surprise measures are interacted with a dummy variable $\iota_{j,t}$ that takes the value of one when the announcement is classified as growth, risk or monetary news. Specifically, we run the following regression $\Delta r_{i,t} = \alpha_j + \theta_j' Z_t + (\gamma_{j,growth}' \iota_{j,t}^{growth} + \gamma_{j,risk}' \iota_{j,t}^{risk} + \gamma_{j,MP}' \iota_{j,t}^{MP}) MPS_{j,t} + \varepsilon_{j,t}$ and report $\hat{\gamma}_j$s. Reported coefficients measure the pass-through from monetary policy surprises to 10-year government bond yield, differentiated across the types of monetary policy surprises. t-statistics based on Panel-Corrected Standard Errors (PCSE) are given in parentheses. Cells coloured red (green) indicate statistically significant positive (negative) coefficients at a 10% confidence level.

Table 7: Macroeconomic Links and Spillovers

	Advanced economies				Emerging market economies			
	Target	Path	Long-rate	R^2	Target	Path	Long-rate	R^2
Panel A. Exports								
Fed	0.09	0.04	0.06	14%	0.00	-0.31	-0.06	6%
	(1.53)	(1.41)	(2.05)		(-0.03)	(-4.11)	(-0.71)	
ECB	0.10	0.08	0.06	14%	0.25	0.11	0.20	0%
	(2.97)	(2.74)	(1.82)		(0.80)	(0.42)	(0.55)	
ECB (excl.EA)	-0.06	0.00	-0.06	33%	–	–	–	–
	(-1.52)	(0.01)	(-1.42)		–	–	–	
Panel B. Imports								
Fed	0.06	0.04	0.05	14%	-0.03	-0.28	-0.09	6%
	(1.12)	(1.61)	(2.05)		(-0.21)	(-3.91)	(-1.15)	
ECB	0.06	0.05	0.05	14%	0.24	0.16	0.21	0%
	(1.88)	(1.87)	(1.30)		(0.68)	(0.57)	(0.52)	
ECB (excl.EA)	-0.06	0.00	-0.06	33%	–	–	–	–
	(-1.54)	(0.08)	(-1.40)		–	–	–	
Panel C. Inflation correlation								
Fed	0.55	0.32	0.52	16%	-0.59	-1.27	-0.82	7%
	(1.88)	(2.33)	(3.30)		(-0.65)	(-2.92)	(-1.74)	
ECB	0.48	0.41	0.34	14%	-1.58	-0.40	-2.16	1%
	(3.03)	(3.04)	(1.79)		(-1.69)	(-0.56)	(-2.18)	
ECB (excl.EA)	-0.15	-0.04	-0.08	34%	–	–	–	–
	(-0.98)	(-0.28)	(-0.43)		–	–	–	
Panel D. Growth correlation								
Fed	0.61	0.43	0.39	16%	-0.68	0.24	-0.68	4%
	(1.92)	(2.55)	(2.32)		(-0.96)	(0.78)	(-2.19)	
ECB	0.28	0.21	0.17	14%	0.94	0.20	0.45	1%
	(2.00)	(1.76)	(0.94)		(2.24)	(0.54)	(1.28)	
ECB (excl.EA)	0.06	-0.05	0.10	35%	–	–	–	–
	(0.45)	(-0.42)	(0.66)		–	–	–	

Notes: This table reports the results of panel regressions as given by Equation (2) with various recipient specific conditioning variables $X_{i,t-1}$ measuring bilateral macroeconomic interlinkages of originators and recipients. The dependent variable is the daily change in 10-year bond yields in our set of 47 recipient countries. Results are reported for separate panel regressions for advanced economies and emerging market economies. As regressors, besides the monetary surprises for the ECB and the Fed, specifications also include the daily change in the US Treasury yield and the VIX as global controls (not reported). The reported coefficients correspond to the interaction term, $\hat{\gamma}_j$, in Equation (2). t-statistics based on Panel-Corrected Standard Errors (PCSE) are given in parentheses. Cells coloured red (green) indicate statistically significant positive (negative) coefficients at a 10% confidence level. Inflation correlation and growth correlation are measured as 20-year rolling correlation of realized CPI inflation and realized real GDP growth for the country pair, respectively. Imports and exports (% of GDP) are measured in standard deviations from the mean.

Table 8: FX Regime and Spillovers

	Advanced economies				Emerging market economies			
	Target	Path	Long-rate	R^2	Target	Path	Long-rate	R^2
Fed	-0.20	-0.03	-0.29	16%	0.02	0.01	0.05	10%
	(-0.66)	(-0.25)	(-2.68)		(5.25)	(3.41)	(6.74)	
ECB	-0.34	-0.43	-0.22	14%	-1.00	-1.10	-1.06	0%
	(-2.36)	(-3.19)	(-1.25)		-0.91	-1.17	-0.86	
ECB (excl.EA)	-0.30	-0.48	-0.21	32%	–	–	–	–
	(-2.50)	(-4.20)	(-1.43)		–	–	–	

Notes: This table reports the results of panel regressions as given by by Equation (2) with the recipient-specific conditioning variable $X_{i,t-1}$ capturing the FX regime via the bilateral FX volatility with respect to shock originating countries. The dependent variable is the daily change in 10-year bond yields in our set of 47 recipient countries. Results are reported for separate panel regressions for advanced economies and emerging market economies. As regressors, besides the monetary surprises for the ECB and the Fed, specifications also include the daily change in the US Treasury yield and the VIX as global controls (not reported). The reported coefficients correspond to the interaction terms, $\hat{\gamma}_j$, in Equation (2) and measure the pass-through of spillovers to recipients' interest rates, conditional on our FX volatility measure. t-statistics from Panel-Corrected Standard Errors (PCSE) are given in parentheses. Cells coloured red (green) indicate statistically significant positive (negative) coefficients at a 10% confidence level. FX volatility is measured as a 1-year rolling realized volatility estimate, based on squared daily spot FX changes (%).

Table 9: Financial Links and Spillovers

	Advanced economies				Emerging market economies			
	Target	Path	Long-rate	R^2	Target	Path	Long-rate	R^2
Panel A. Foreign currency debt								
Fed	0.06	0.06	0.02	15%	0.04	-0.21	-0.17	6%
	(1.52)	(3.06)	(1.14)		(0.13)	(-1.96)	(-1.52)	
ECB	0.03	0.02	0.04	14%	0.01	0.22	-0.02	0%
	(1.03)	(0.90)	(1.32)		(0.02)	(0.53)	(-0.04)	
ECB (excl.EA)	0.11	0.10	0.10	32%				
	(3.42)	(4.23)	(3.25)					
Panel B. Portfolio debt from originator country								
Fed	0.04	0.06	0.06	14%	-0.19	-0.06	-0.03	6%
	(0.86)	(2.48)	(1.78)		(-1.33)	(-0.85)	(-0.41)	
ECB	0.12	0.09	0.10	12%	0.34	0.18	0.37	1%
	(2.34)	(2.51)	(2.08)		(2.44)	(1.70)	(2.88)	
ECB (excl.EA)	0.16	0.13	0.12	35%				
	(3.80)	(3.97)	(3.31)					
Panel C. Portfolio equity from originator country								
Fed	0.06	0.02	0.03	14%	0.20	0.12	0.15	6%
	(1.08)	(0.83)	(0.68)		(1.34)	(1.51)	(1.87)	
ECB	0.14	0.12	0.08	12%	-0.05	0.05	0.02	0%
	(3.32)	(4.04)	(2.37)		(-0.44)	(0.56)	(0.17)	
ECB (excl.EA)	0.04	0.05	0.05	34%				
	(1.61)	(2.64)	(1.92)					
Panel D. Portfolio debt to originator country								
Fed	-0.01	0.00	-0.01	13%	-0.08	-0.42	-0.22	8%
	(-0.21)	(0.24)	(-0.48)		(-0.60)	(-5.75)	(-1.80)	
ECB	0.19	0.12	0.15	12%	0.17	-0.14	-0.06	0%
	(4.21)	(3.63)	(3.17)		(1.70)	(-1.35)	(-0.74)	
ECB (excl.EA)	0.11	0.09	0.13	34%				
	(3.13)	(3.41)	(3.56)					
Panel E. Portfolio equity to originator country								
Fed	0.02	0.04	0.04	14%	-0.10	-0.20	-0.03	7%
	(0.46)	(1.34)	(1.07)		(-0.73)	(-3.23)	(-0.33)	
ECB	0.16	0.11	0.14	13%	0.03	-0.06	0.05	0%
	(3.49)	(3.38)	(3.32)		(0.33)	(-0.81)	(0.73)	
ECB (excl.EA)	0.08	0.08	0.10	35%				
	(2.07)	(3.17)	(2.76)					

Notes: This table reports the results of panel regressions as given by Equation (2) with various recipient specific conditional variable $X_{i,t-1}$ measuring bilateral financial links between recipients and originators. The dependent variable is the daily change in 10-year bond yields in our set of 47 recipient countries. Results are shown separately for advance economy and emerging market recipients. As regressors, besides the monetary surprises for the ECB and the Fed, specifications also include the daily change in the US Treasury yield and the VIX as global controls (not reported). The reported coefficients correspond to the interaction term, $\hat{\gamma}_j$, in Equation (2) and measure the pass-through conditional the respective financial linkage measure. t-statistics based on Panel Corrected Standard Errors (PCSE) are given in parentheses. Cells coloured red (green) indicate statistically significant positive (negative) coefficients at a 10% confidence level. Financial flows (% of GDP) are measured in standard deviations from the mean.

Table 10: Discriminating among Spillover Channels

	Macroeconomic links (Growth correlation)			FX regime (FX volatility)			Financial links (Portfolio debt)			
	Target	Path	Long-rate	Target	Path	Long-rate	Target	Path	Long-rate	R^2
Panel A. Advanced economies										
Fed	0.11	0.22	0.00	0.36	0.11	-0.14	0.02	0.04	0.09	14%
	(0.28)	(1.02)	(0.02)	(0.97)	(0.67)	(-1.11)	(0.19)	(1.01)	(1.89)	
ECB	0.14	-0.13	-0.14	0.13	-0.33	0.03	0.13	0.10	0.19	13%
	(0.59)	(-0.71)	(-0.50)	(0.50)	(-1.38)	(0.10)	(1.57)	(1.77)	(2.45)	
ECB (excl.EA)	-0.16	-0.18	-0.14	-0.07	-0.50	-0.23	0.17	0.08	0.12	39%
	(-1.14)	(-1.65)	(-0.93)	(-0.41)	(-3.40)	(-1.26)	(3.62)	(2.33)	(2.94)	
Panel B. Emerging market economies										
Fed	-0.68	0.16	-0.96	0.02	0.01	0.06	-0.09	0.06	0.22	9%
	(-0.73)	(0.37)	(-2.24)	(10.15)	(7.34)	(12.63)	(-0.42)	(0.64)	(2.60)	
ECB	-1.32	-0.40	-1.56	-2.95	-0.35	-1.93	1.26	0.45	1.18	3%
	(-1.53)	(-0.79)	(-2.08)	(-2.08)	(-0.26)	(-1.30)	(2.19)	(1.17)	(2.94)	

Notes: This table reports the results of panel regression as given by Equation (2) with recipient-specific conditional variables, included jointly to determine the relative importance of spillover channels. $X_{i,t-1}$ includes (i) growth correlation with shock originating countries (macroeconomic links channel), (ii) FX volatility with respect to currencies in surprise originating countries (FX regime channel), (iii) and portfolio debt from originating countries (financial links channel). The dependent variable is the daily change in 10-year bond yields in our set of 47 recipient countries. As regressors, besides the monetary surprises for the ECB and the Fed, specifications also include the daily change in the US Treasury yield and the VIX as global controls (not reported). The reported coefficients correspond to the interaction terms, $\hat{\gamma}_j$, in Equation (2). t-statistics based on Panel-Corrected Standard Errors(PCSE) are given in parentheses. Cells coloured red (green) indicate statistically significant positive (negative) coefficients at a 10%confidence level. Financial flows (% of GDP) are measured in standard deviations from the mean.

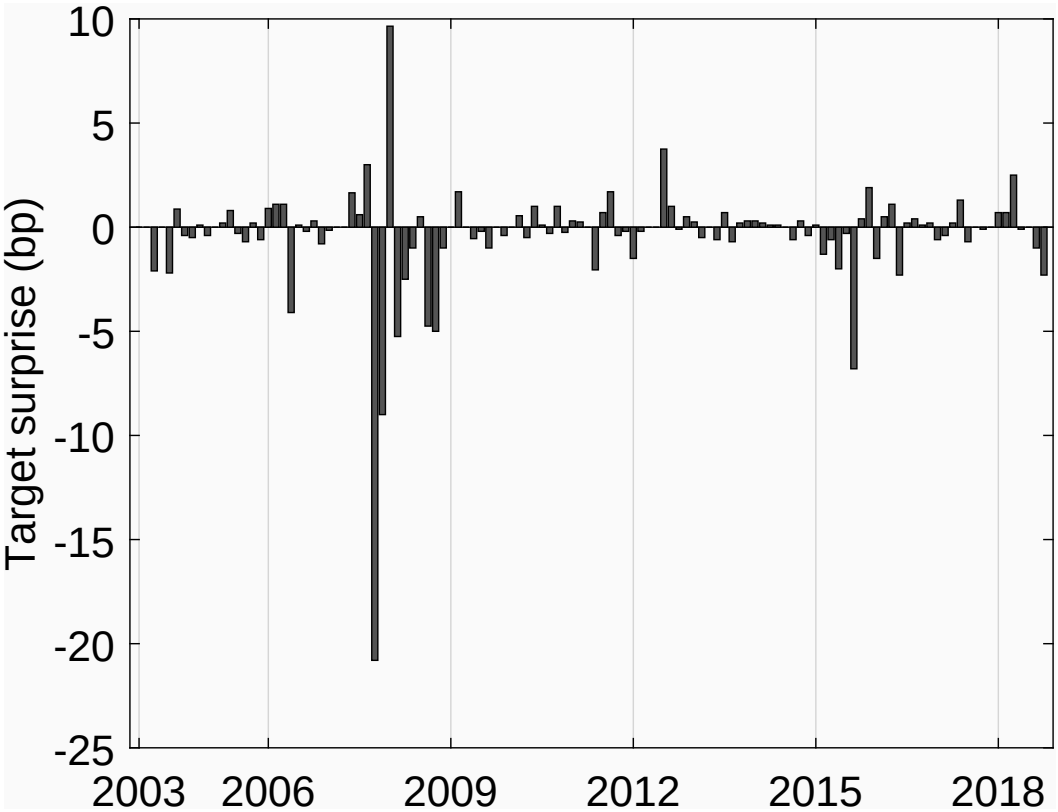
Online Appendix for

Explaining Monetary Spillovers: The Matrix Reloaded

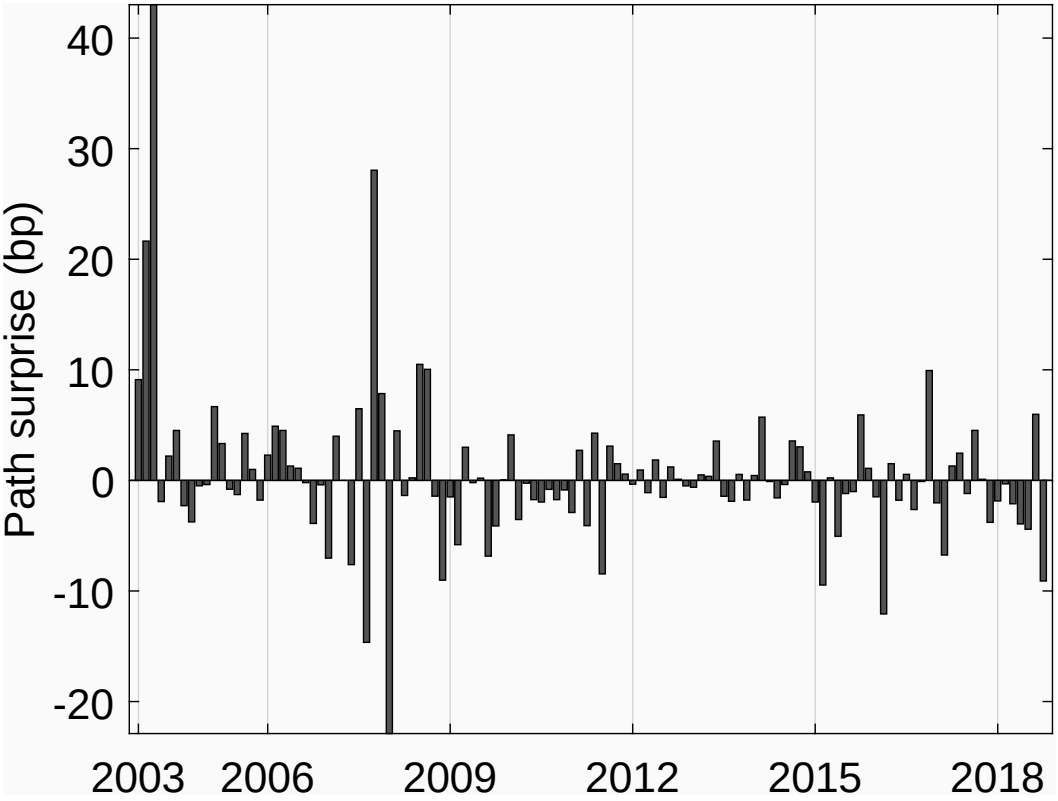
(not for publication)

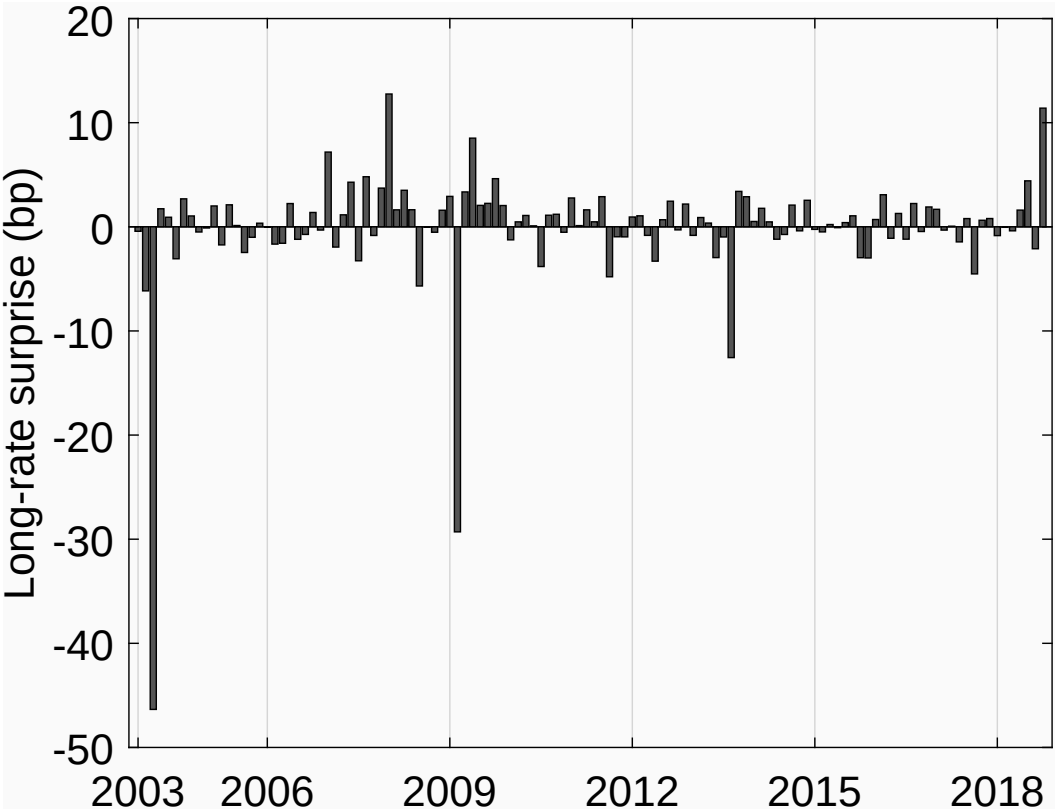
Figure IA.1: Fed Monetary Policy Surprises

(a) Target



(b) Path



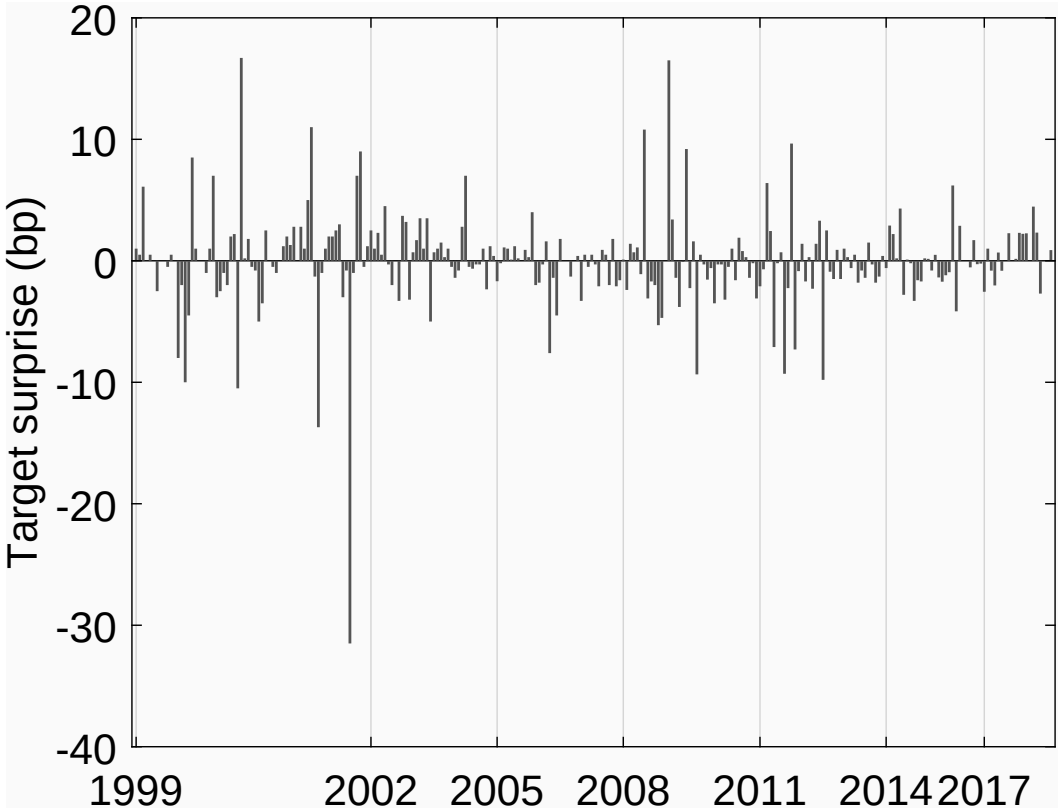


(c) Long-rate

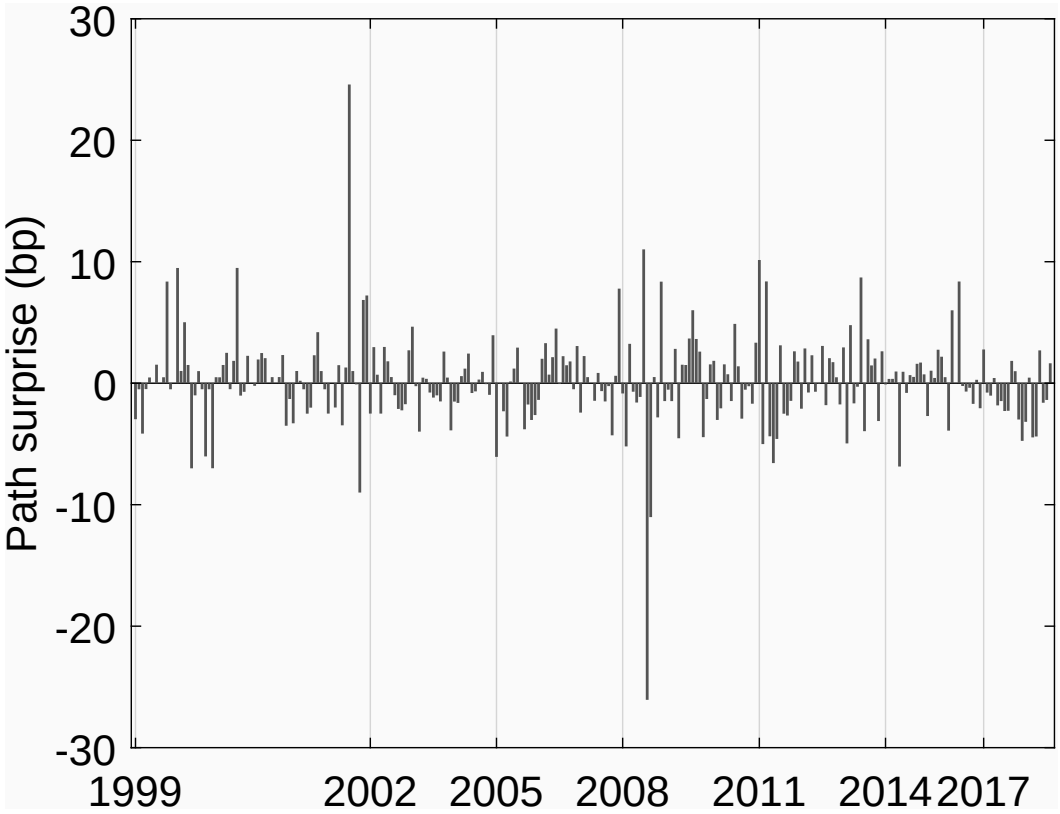
Notes: The figure depicts monetary policy surprises by the Federal Reserve computed following Equation 3 in the main text. We differentiate target, path and long-rate surprises as described in the text. The sample ranges from December 2003 to June 2019, with 120 observations.

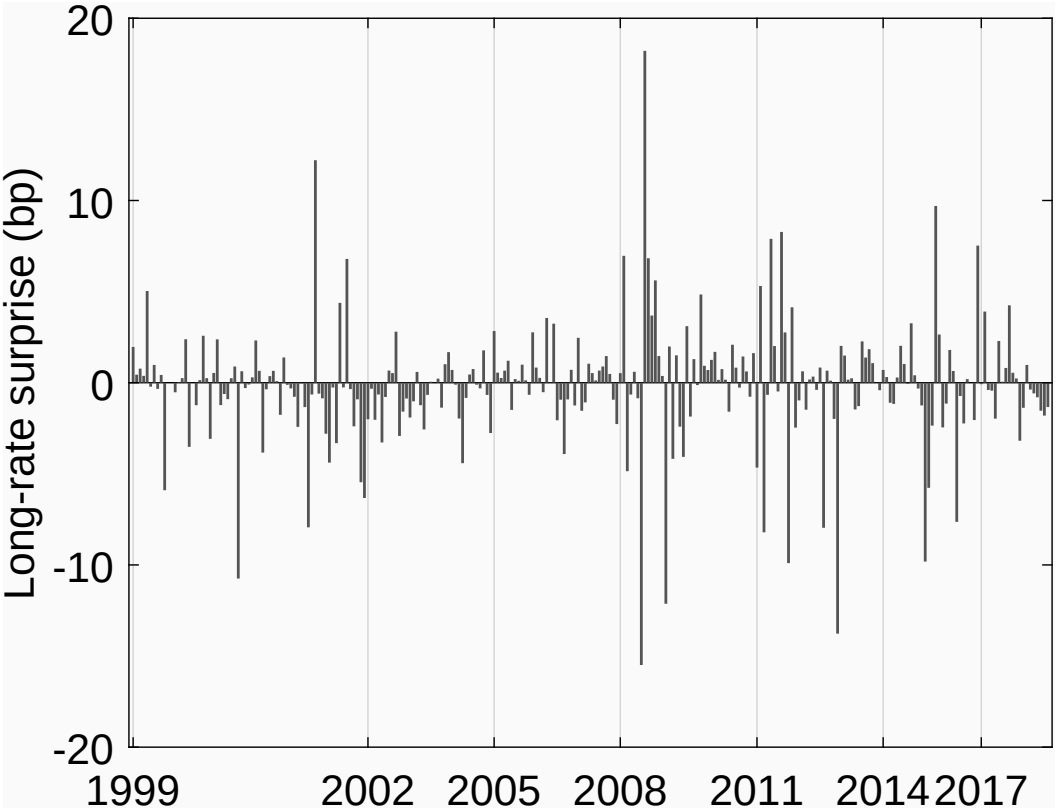
Figure IA.2: ECB Monetary Policy Surprises

(a) Target



(b) Path



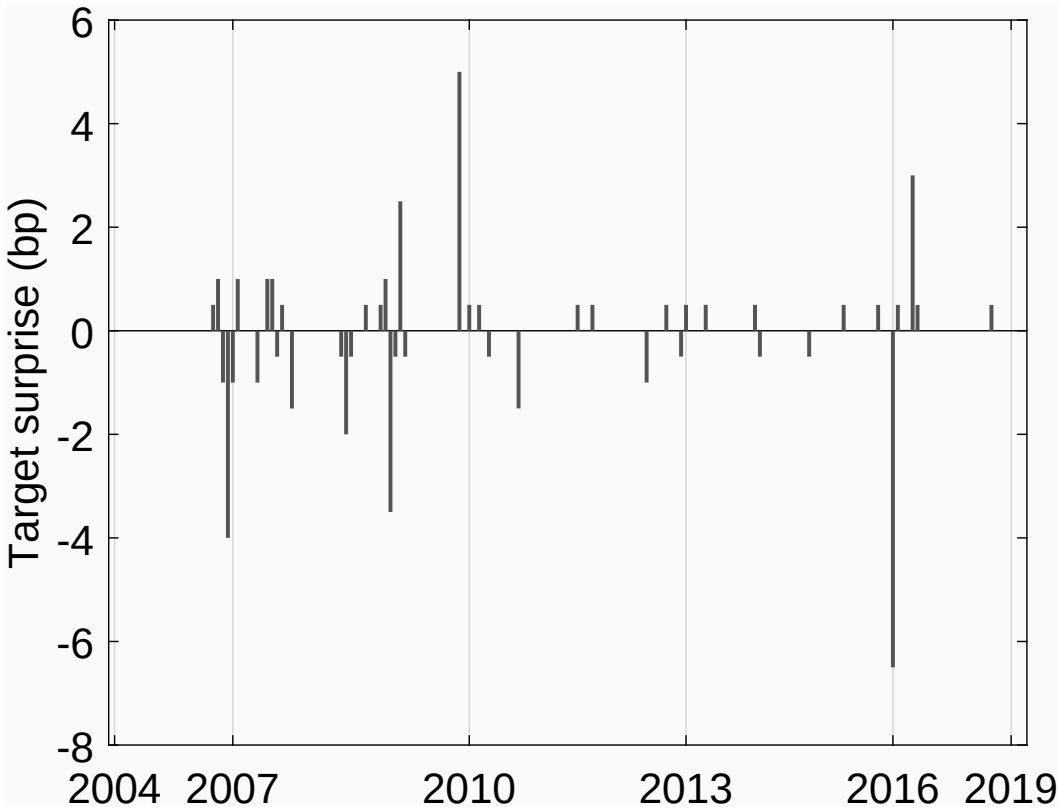


(c) Long-rate

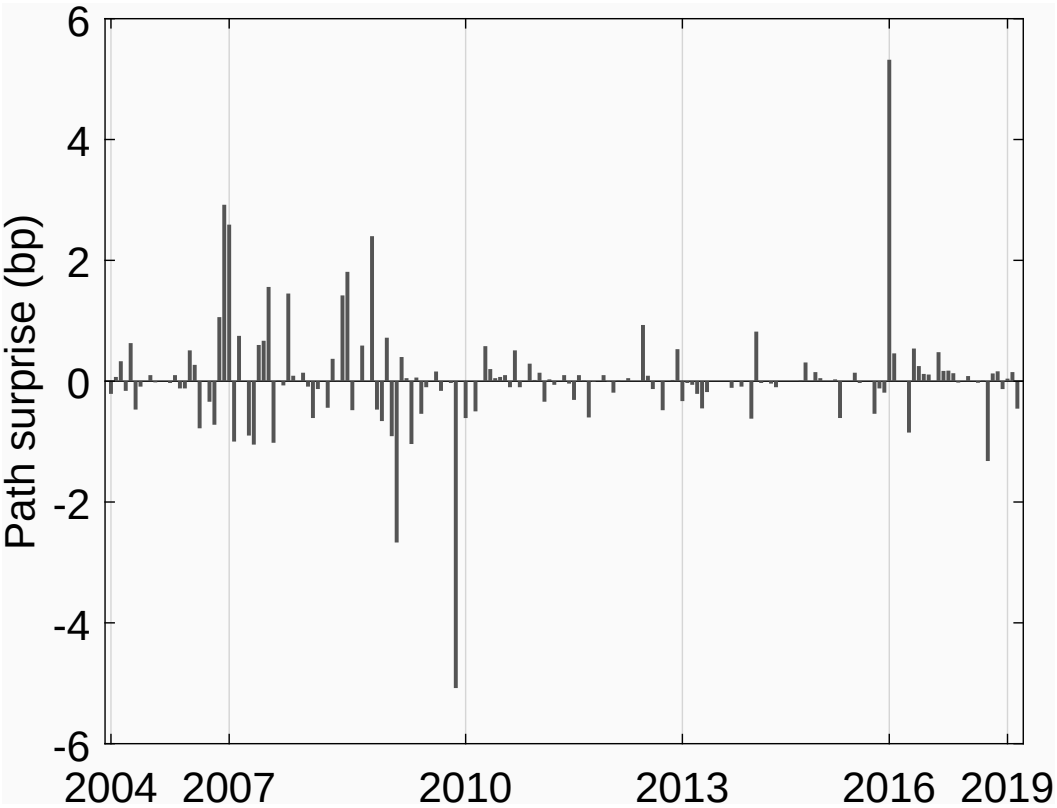
Notes: The figure depicts monetary policy surprises by the ECB computed following Equation 3 in the paper. We differentiate target, path and long-rate surprises as described in the text. The sample ranges from March 1999 to June 2019, with 262 observations.

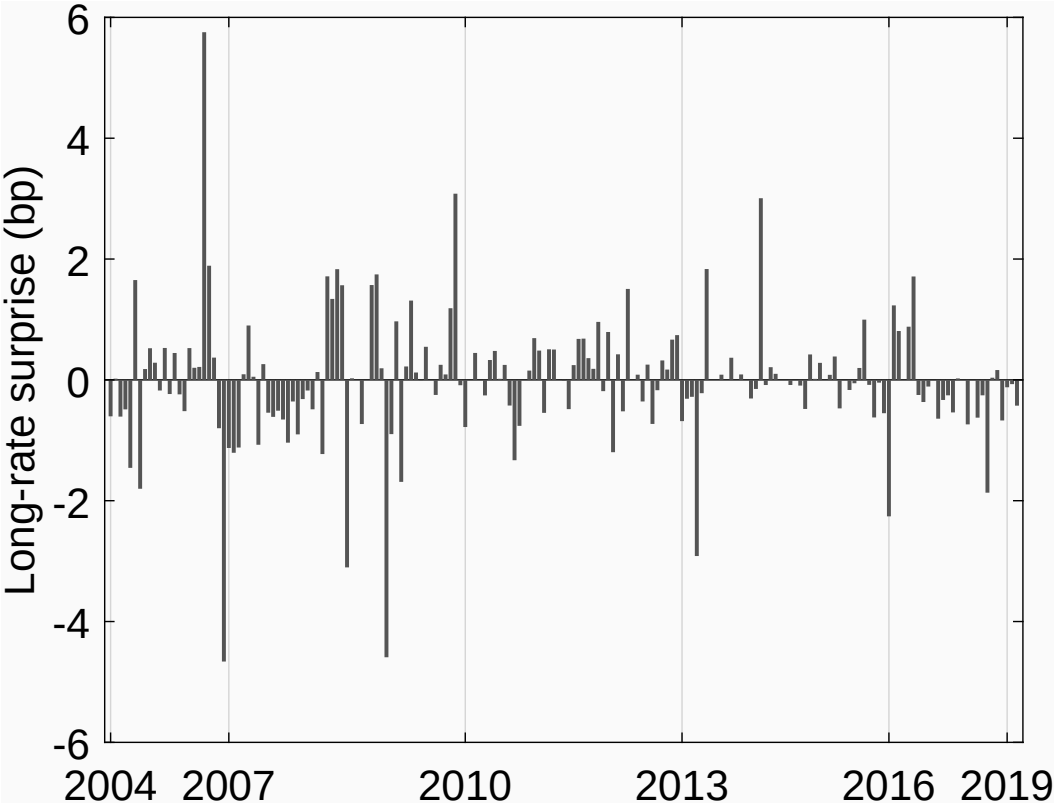
Figure IA.3: BoJ Monetary Policy Surprises

(a) Target



(b) Path



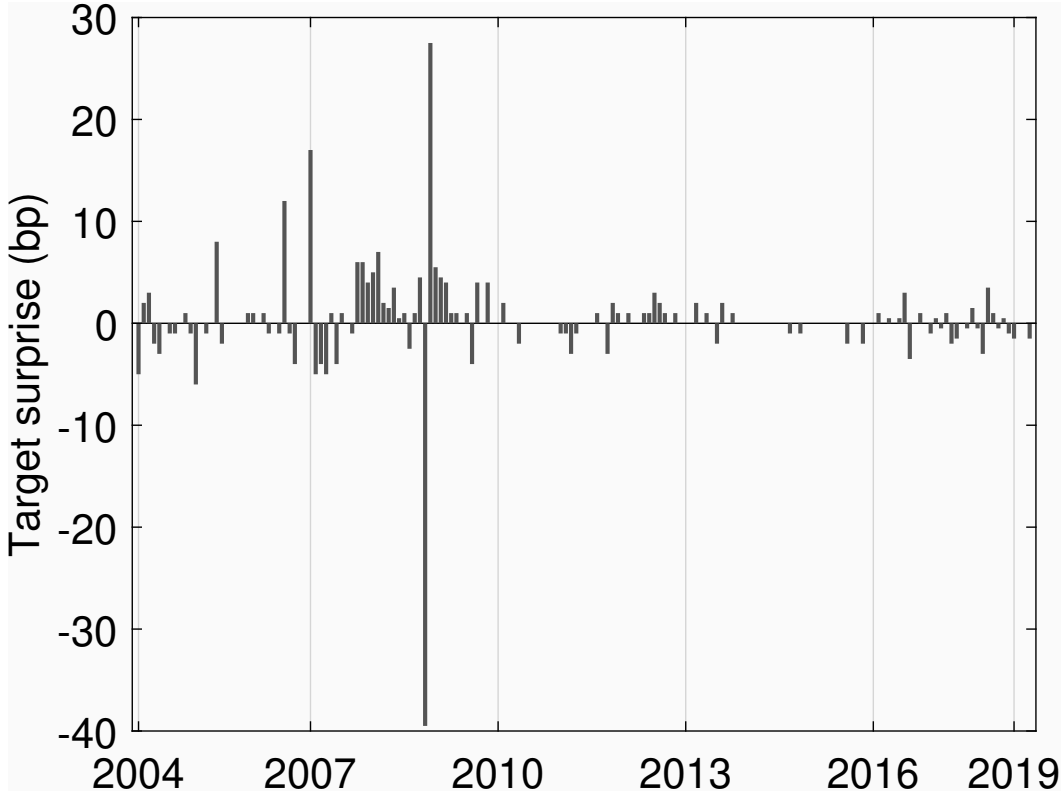


(c) Long-rate

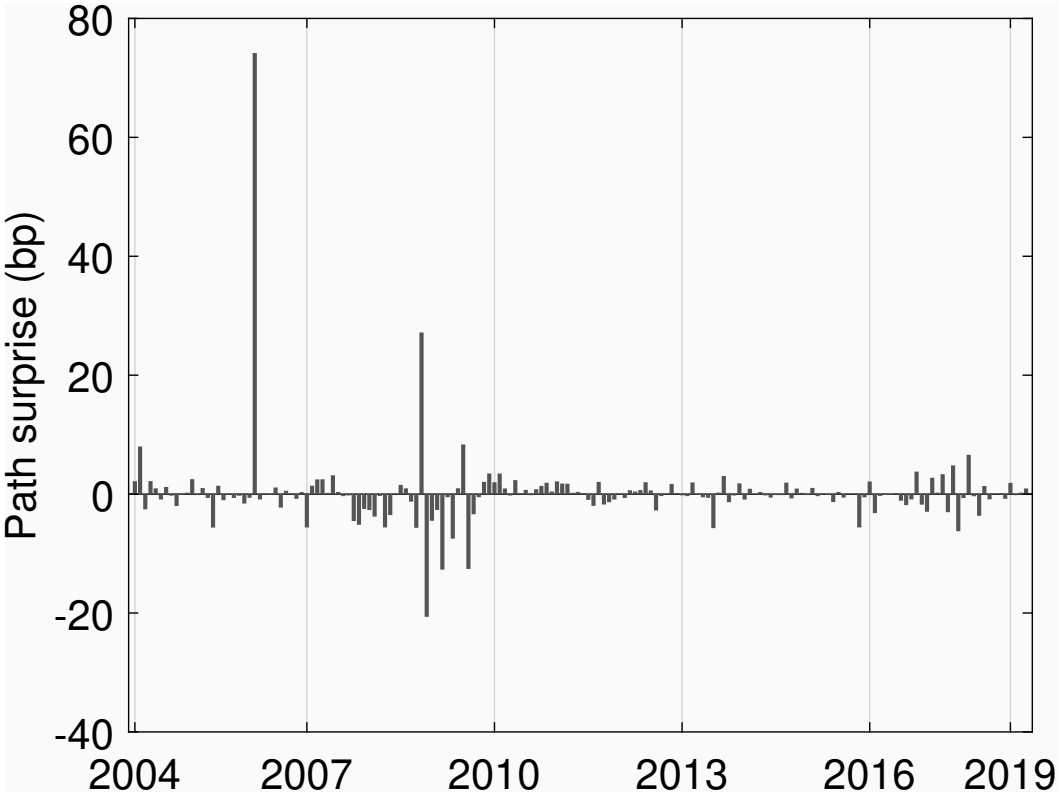
Notes: The figure depicts monetary policy surprises by the Bank of Japan computed following Equation 3 in the paper. We differentiate target, path and long-rate surprises as described in the text. The sample ranges from April 2004 December to June 2019, with 185 observations.

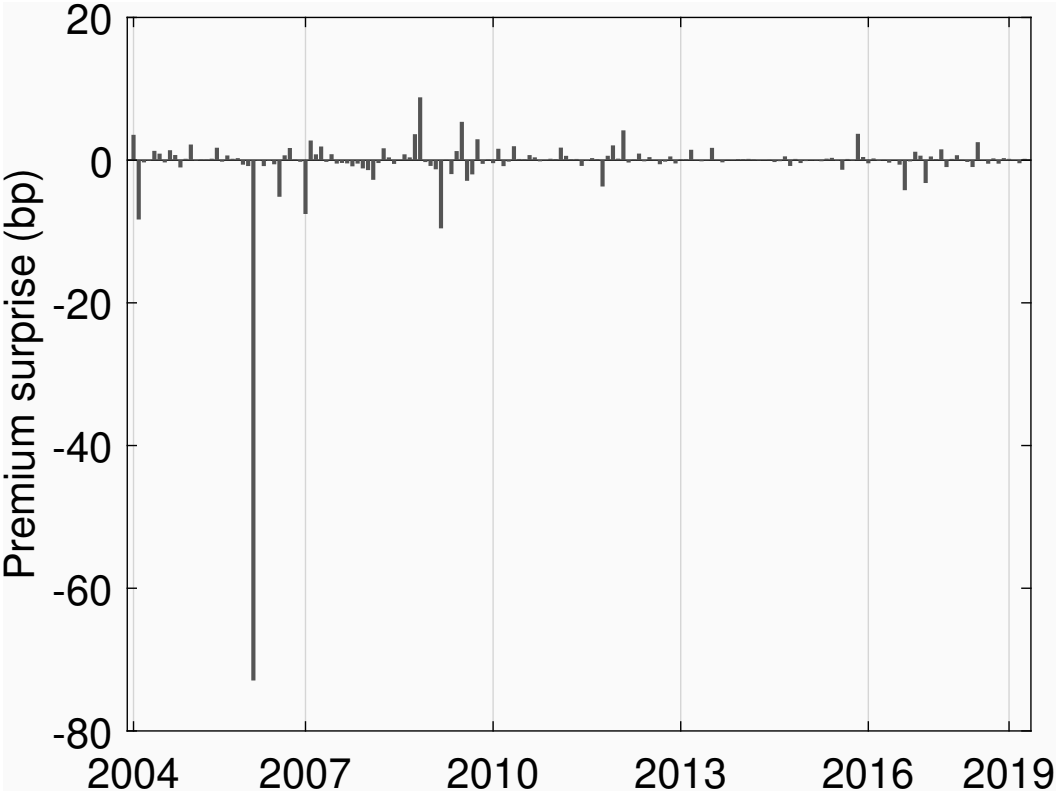
Figure IA.4: BoE Monetary Policy Surprises

(a) Target



(b) Path



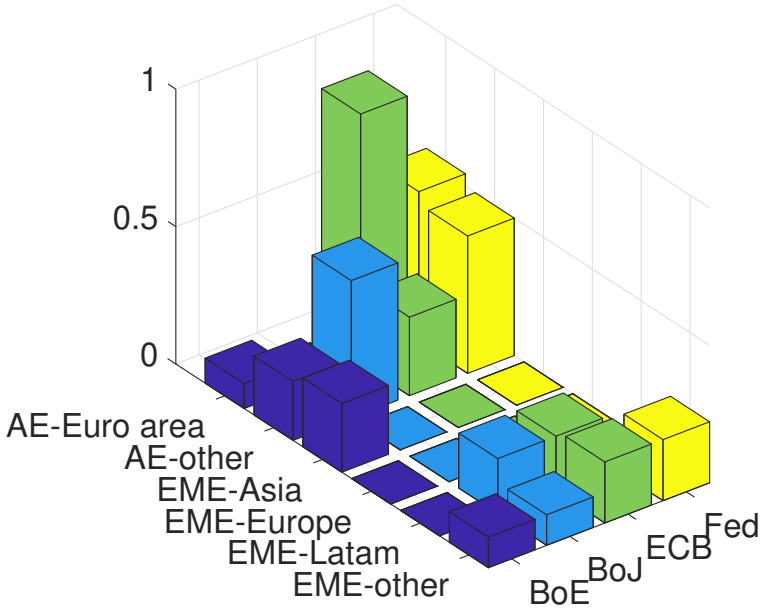


(c) Long-rate

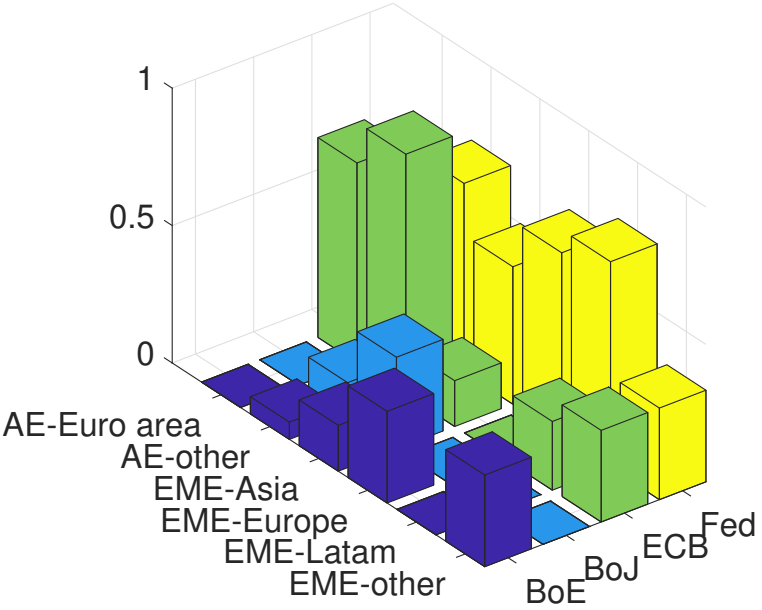
Notes: The figure depicts monetary policy surprises by the Bank of England computed following Equation 3 in the paper. We differentiate target, path and long-rate surprises as described in the text. The sample ranges from April 2004 to June 2019, with 172 observations.

Figure IA.5: Global Spillover Matrix for 6-Month Short Rates and 2-Year Bond Yields

(a) 6-month



(b) 2-year



Notes: The figure plots the fraction of countries in each world region receiving a significant spillover from monetary policy surprises originating from the four major central banks (summarising the regression results of Equation (1) for 47 recipient countries). The originator central banks are the Federal Reserve Bank (Fed), European Central Bank (ECB), Bank of Japan (BoJ) and Bank of England (BoE). The data sample spans from April 2004 to June 2019. Panel (a) and (b) refer to spillovers to 6-month interest rates and 2-year bond yields, respectively. A spillover is counted as significant if the p-value from the F-test of joint significance of $\widehat{\beta}_{ij}$ coefficients in Equation (1) is less than 10%.

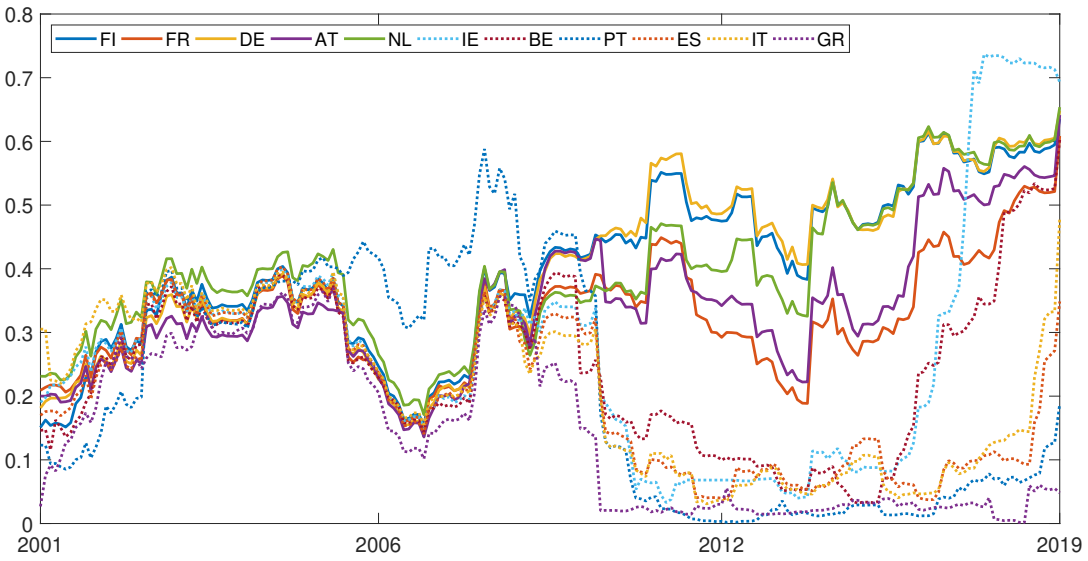
Figure IA.6: Global Spillover Map from BoJ for 10-Year Bond Yields

Notes: The figure provides a global map that shows the intensity of monetary policy spillovers generated by the Bank of Japan to 10-year bond yields of 47 recipient countries around the globe. Spillover strength is measured based on the R^2 of the regression of the individual countries' 10-year bond yields on Fed monetary policy surprises (following Equation (1)). The sample period spans from April 2004 to June 2019.

Figure IA.7: Global Spillover Map from BoE for 10-Year Bond Yields

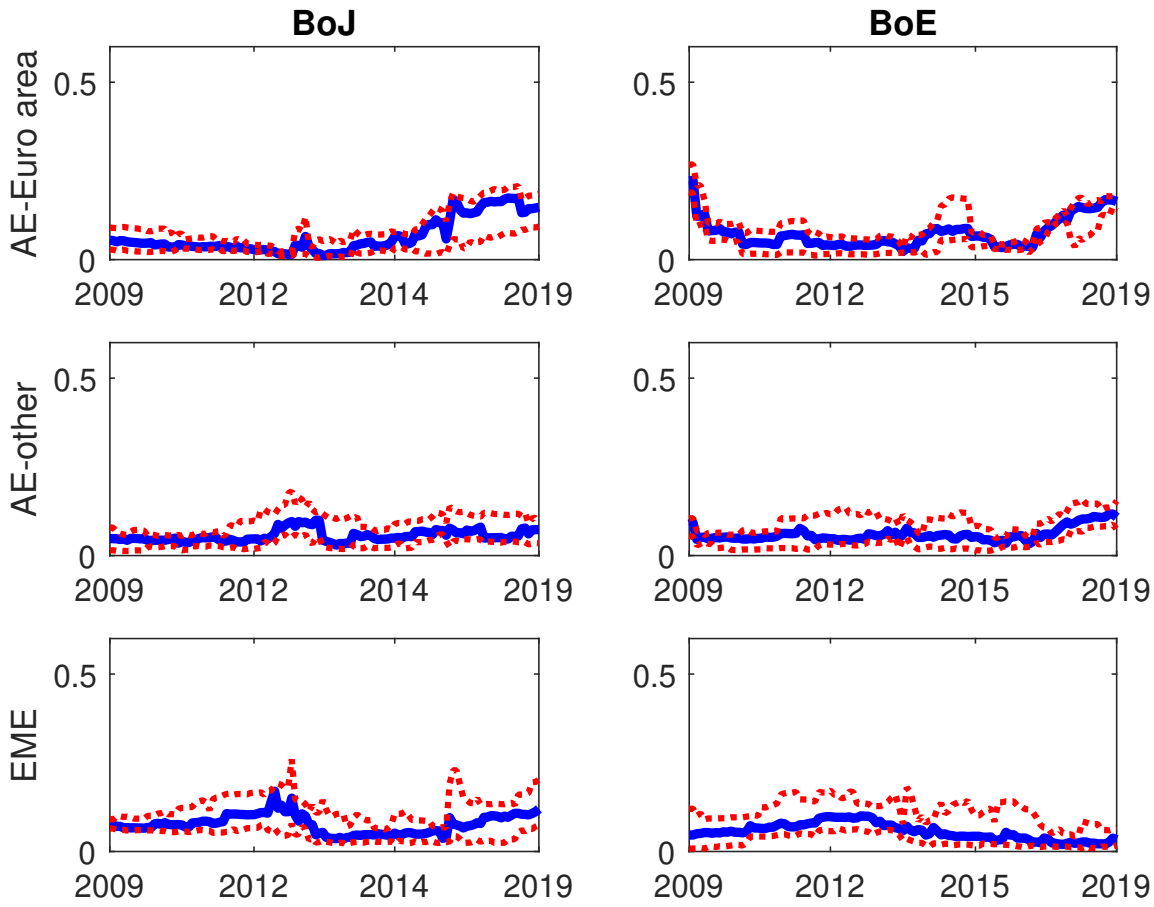
Notes: The figure provides a global map that shows the intensity of monetary policy spillovers generated by the Bank of England to 10-year bond yields of 47 recipient countries around the globe. Spillover strength is measured based on the R^2 of the regression of the individual countries' 10-year bond yields on Fed monetary policy surprises (following Equation (1)). The sample period spans from April 2004 to June 2019.

Figure IA.8: ECB Monetary Policy Surprises and Euro Area Countries' Bond Yield Response



Notes: The figure shows how the importance of monetary policy spillovers originating from the ECB for euro area long-term bond yields varies over time. To measure spillover strength, we perform a rolling window regression with 60 observations based on Equation (1). The graph shows the evolution in the R^2 from the regression for individual countries' 10-year bond yields. Solid lines are for core countries including Finland (FI), France (FR), Germany (DE), Austria (AT) and Netherlands (NL). Dashed lines are for peripheral countries including Ireland (IE), Belgium (BE), Portugal (PT), Spain (ES), Italy (IT) and Greece (GR).

Figure IA.9: Time-variation in Spillover Importance from BoJ and BoE



Notes: The figure shows how the importance of monetary policy spillovers originating from the BoJ and BoE to long-term bond yields varies over time. To measure spillover strength, we perform a rolling window regression with 60 observations based on Equation (1) for the 47 recipient countries. The graph shows the median and 25% to 75% interquartile range of the R^2 from the regression.

Table IA.1: Instruments for Measurement of Monetary Policy Surprises

	3-month		**2-year**		**10-year**	
	Instrument	RIC	Instrument	RIC	Instrument	RIC
Fed	OIS	USD3MOIS	futures	TUc1	futures	TYc1
ECB	OIS	EUREON3M	futures	FGBSc1	futures	FGBLc1
BoJ	futures	JEYcm1	cash	JPGOV2YZ	futures	JGBc1
BoE	futures	FSScm1	cash	GBGOV2YZ	futures	FLGc1

Notes: The table summarises the fixed income instruments (OIS, cash bonds, and futures) and data sources for intraday data used for the measurements of monetary policy surprises for the different currency areas. RIC denotes the corresponding data field in Thomson Reuters.

Table IA.2: List of Spillover Recipient Countries

Advanced (27)		Emerging market (20)			
Euro area	Other	Asia	Europe	Latin America	Other
Austria	Australia	China	Poland	Brazil	Nigeria
Belgium	Canada	India	Romania	Chile	Pakistan
Finland	Czech Republic	Indonesia	Turkey	Colombia	Russia
France	Denmark	Malaysia		Mexico	South Africa
Germany	Hong Kong	Philippines		Peru	
Greece	Israel	Thailand		Venezuela	
Ireland	Japan	Vietnam			
Italy	Korea				
Netherlands	New Zealand				
Portugal	Norway				
Spain	Singapore				
	Sweden				
	Switzerland				
	Taiwan				
	United Kingdom				
	United States				

Table IA.3: Overview of Sources for Recipient Countries' Interest Rates

Country	1-month (or 3-month) interest rate Bloomberg code	6-month interest rate Bloomberg code	2-year bond yield Bloomberg code	10-year bond yield Bloomberg code
Australia	SWAP OIS 1M	SWAP OIS 6M		
	ADSOA Curncy	ADSOF Curncy	GACGB2 Index	GACGB10 Index
Austria	Vienna Interbank Offer Rate 1M	Vienna Interbank Offer Rate 6M		
	VIBO1M Index	VIBO6M Index	GTATS2Y Govt	GTATS10Y Govt
Belgium	Belgium Treasury Bills 1M	Belgium Treasury Bills 6M		
	GBGT1MO Index	GBGT6MO Index	GTBEF2Y Govt	GTBEF10Y Govt
Brazil	Retail Certificate of Deposit 1M	Retail Certificate of Deposit 6M		
	BCCDBAE Curncy	BCCDBFE Curncy	GTBRL2Y Govt	GTBRL10Y Govt
Canada	SWAP OIS 1M	SWAP OIS 6M		
	CDSOA Curncy	CDSOF Curncy	GCAN2YR Index	GCAN10YR Index
Chile	TAB Nominal Interbank Rate 30D	TAB Nominal Interbank Rate 180D		
	CLTN30DN Index	CLTN180N Index	GTCLP2Y Govt	GTCLP10Y Govt
China	SWAP OIS 1M (onshore)	SWAP OIS 6M (onshore)		
	CCSOOA Curncy	CCSOOF Curncy	GTCNY2Y Govt	GTCNY10Y Govt
Colombia	OIS X IBR 1M	OIS X IBR 6M		
	CLSWIBA Curncy	CLSWIBF Curncy	GTCOP2Y Govt	GTCOP10Y Govt
Czech Republic	SWAP OIS 1M	SWAP OIS 6M		
	CKSOA Curncy	CKSOF Curncy	CZGB2YR Index	CZGB10YR Index
Denmark	OIS T/N INDEXED 1M	OIS T/N INDEXED 6M		
	DKSWTNA Curncy	DKSWTNF Curncy	GDGB2YR Index	GDGB10YR Index
Finland	LIBOR EUR 1M	LIBOR EUR 6M		
	EE0001M Index	EE0006M Index	GTFIM2Y Govt	GTFIM10Y Govt
France	Treasury Bills 1M	Treasury Bills 6M		
	GBTF1MO Index	GBTF6MO Index	GFRN2 Index	GFRN10 Index
Germany	Treasury discount paper (Bubills) 1M	Treasury discount paper (Bubills) 6M		
	GETB1M Index	GETB2 Index	GDBR2 Index	GDBR10 Index
Greece	govt 3M benchmark	govt 6M benchmark		
	GGGB3M Index	GGGB6M Index	GGGB2YR Index	GGGB10YR Index
Hong Kong	Hong Kong Treasury Bill 1M	Hong Kong Treasury Bill 6M		
	GTHKD1M Govt	GTHKD6M Govt	GTHKD2Y Govt	GTHKD10Y Govt
India	SWAP OIS 1M (onshore)	SWAP OIS 6M (onshore)		
	IRSWOA Curncy	IRSWOF Curncy	GTINR2Y Govt	GTINR10Y Govt
Indonesia	SWAP OIS 1M (onshore)	SWAP OIS 6M (onshore)		
	IHSWOOA Curncy	IHSWOOF Curncy	GTIDR2Y Govt	GTIDR10Y Govt

Overview of Sources for Recipient Countries' Interest Rates (cont.)

Country	1-month (or 3-month) interest rate Bloomberg code	6-month interest rate Bloomberg code	2-year bond yield Bloomberg code	10-year bond yield Bloomberg code
Ireland	Dublin Interbank Offered Rates 1M	Dublin Interbank Offered Rates 6M		
	DIBO01M Index	DIBO06M Index	GIGB2YR Index	GIGB10YR Index
Israel	SWAP OIS 1M	SWAP OIS 6M		
	ISSOA Curncy	ISSOF Curncy	GISR2YR Index	GISR10YR Index
Italy	Treasury Bills (BOTs) 3M	Treasury Bills (BOTs) 6M		
	GBOTG3M Index	GBOTG6M Index	GTITL2Y Govt	GTITL10Y Govt
Japan	SWAP OIS 1M	SWAP OIS 6M		
	JYSOA Curncy	JYSOF Curncy	GTJPY2Y Govt	GTJPY10Y Govt
Korea	SWAP OIS 1M (onshore)	SWAP OIS 6M (onshore)		
	KWSWOOA Curncy	KWSWOOF Curncy	GTKRW2Y Govt	GTKRW10Y Govt
Malaysia	SWAP OIS 1M (onshore)	SWAP OIS 6M (onshore)		
	MRSOA Curncy	MRSOF Curncy	MGIY2Y Index	GTMYR10Y Govt
Mexico	CETES Auction Average 28D	CETES Auction Average 182D		
	GCETAA28 Index	GCETAA18 Index	GTMXN2Y Govt	GTMXN10Y Govt
Netherlands	Amsterdam Interbank Offered Rate 1M	Amsterdam Interbank Offered Rate 6M		
	AIBO1M Index	AIBO6M Index	GTNLG2Y Govt	GTNLG10Y Govt
New Zealand	SWAP OIS 1M	SWAP OIS 6M		
	NDSOA Curncy	NDSOF Curncy	GNZGB2 Index	GNZGB10 Index
Nigeria	Interbank Treasury Bills 1M	Interbank Treasury Bills 6M		
	NITTY1M Index	NITTY6M Index	GTNGN1Y Govt	GTNGN10Y Govt
Norway	1 Month Deposit	6 Month Deposit		
	NKDRA Curncy	NKDRF Curncy	GNOR2YR Index	GNOR10YR Index
Pakistan	KIBOR Fixing 1M	KIBOR Fixing 6M		
	PKDP1M Index	PKDP6M Index	GTPKR1Y Govt	GTPKR10Y Govt
Peru	OIS 30D	OIS 180D		
	PSSO30T Curncy	PSSO180T Curncy	GRPE2Y Index	GTPEN10Y Govt
Philippines	SWAP OIS 1M (onshore)	SWAP OIS 6M (onshore)		
	PHSOA Curncy	PHSOF Curncy	GTPHP2Y Govt	GTPHP10Y Govt
Poland	SWAP OIS 1M	SWAP OIS 6M		
	PZSOA Curncy	PZSOF Curncy	POGB2YR Index	POGB10YR Index

Overview of Sources for Recipient Countries' Interest Rates (cont.)

Country	1-month (or 3-month) interest rate Bloomberg code	6-month interest rate Bloomberg code	2-year bond yield Bloomberg code	10-year bond yield Bloomberg code
Portugal	LIBOR EUR 1M	LIBOR EUR 6M		
	EE0001M Index	EE0006M Index	GTPTE2Y Govt	GTPTE10Y Govt
Romania	ROBID-ROBOR 1M	ROBID-ROBOR 6M		
	BUBR1M Index	BUBR6M Index	GTRON2Y Govt	GTRON10Y Govt
Russia	SWAP OIS 1M	SWAP OIS 6M		
	RRSOA Curncy	RRSOF Curncy	RUGE2Y Index	RUGE10Y Index
Singapore	SWAP OIS 1M	SWAP OIS 6M		
	SDSOA Curncy	SDSOF Curncy	MASB2Y Index	MASB10Y Index
South Africa	South Africa Interbank Agreed Rate 1M	South Africa Interbank Agreed Rate 6M		
	JIBA1M Index	JIBA6M Index	GSAB2YR Index	GSAB10YR Index
Spain	Treasury Note 3M	Treasury Note 6M		
	GSPG3M Index	GSPG6M Index	GSPG2YR Index	GSPG10YR Index
Sweden	SWAP OIS 1M	SWAP OIS 6M		
	SKSWTNA Curncy	SKSWTNF Curncy	GSGB2YR Index	GSGB10YR Index
Switzerland	SWAP TOIS 1M	SWAP TOIS 6M		
	SFSWTA Curncy	SFSWTF Curncy	GSWISS02 Index	GSWISS10 Index
Taiwan	Interbank TAIBOR Fixing Rates 1M	Interbank TAIBOR Fixing Rates 6M		
	TAIBOR1M Index	TAIBOR6M Index	GTTWD2Y Govt	GTTWD10Y Govt
Thailand	SWAP ANN (VS O/N) 1M	SWAP ANN (VS O/N) 6M		
	TBNOSA Curncy	TBNOSF Curncy	GTTHB2Y Govt	GTTHB10Y Govt
Turkey	SWAP OIS 1M	SWAP OIS 6M		
	TYSOA Curncy	TYSOF Curncy	GTTRY2Y Govt	GTTRY10Y Govt
United Kingdom	SWAP (vs SONIA) 1M	SWAP (vs SONIA) 6M		
	BPSWSA Curncy	BPSWSF Curncy	GUKG2 Index	GUKG10 Index
United States of America	SWAP OIS 1M	SWAP OIS 6M		
	USSOA Curncy	USSOF Curncy	USGG2YR Index	USGG10YR Index
Venezuela	Certificate Participation 30D	T-Bill Auction Average 182D		
	VNCR30D Index	VLET182Y Index	GTVEF2Y Govt	GTVEF10Y Govt
Vietnam	Deposit 1M	Deposit 6M		
	VDDRA Curncy	VDDRF Curncy	GGVF2YR Index	GGVF10YR Index

Table IA.4: Data Sources

Variable	Description	Source
Interest rates		
1m or 3m rates & 6m OIS	Overnight indexed swaps	Bloomberg & Reuters TickHistoy
2y & 10y yields	Sovereign bond yields	Bloomberg & Reuters TickHistory
Global controls		
U.S. 10y yield	Sovereign benchmark bond yields	
VIX	S&P 500 volatility index	Bloomberg
Economic conditions		
Real GDP	Year-ended growth	BIS, OECD, IMF-WEO
CPI Inflation	Annual rate	BIS, IMF-IFS
Bilateral Trade	Imports and Exports of Goods and Services between Originator and Recipient Country; Ratio to GDP	IMF Direction of Trade Statistics
Common Language	Dummy equals one if Originator and Recipient Share a Common Language	Mayer and Zignago (2011)
Weighted Distance	Distance between Originator and Recipient	Mayer and Zignago (2011)
Time Difference	Time Difference between Originator and Recipient	Mayer and Zignago (2011)

Data Sources (cont.)

Variable	Description	Source
Financial Openness		
Portfolio Equity	Stock of Recipient Country (Total Assets or Liabilities) as a Ratio to GDP	Lane and Milessi Ferretti (2017)
Portfolio Debt	Stock of Recipient Country (Total Assets or Liabilities) as a Ratio to GDP	Lane and Milessi Ferretti (2017)
FDI	Stock of Recipient Country (Total Assets or Liabilities) as a Ratio to GDP	Lane and Milessi Ferretti (2017)
Financial Derivatives	Stock of Recipient Country (Total Assets or Liabilities) as a Ratio to GDP	Lane and Milessi Ferretti (2017)
Bilateral Financial Openness		
Foreign Currency Debt	Country Debt Denominated in USD or EUR as a Ratio to GDP	BIS
Portfolio Equity	Ratio to Recipient Country GDP	Coordinated Portfolio Investment Survey (CPIS), IMF
Portfolio Debt	Ratio to Recipient Country GDP	Coordinated Portfolio Investment Survey (CPIS), IMF
FDI	Ratio to Recipient Country GDP	United Nations Conference on Trade and Development (UNCTAD)
Bank Loans	Ratio to Recipient Country GDP	BIS IBFS

Table IA.5: Classifying Announcements based on Stock-Bond Correlation

	Total	**Growth**	**Risk**	**Monetary Policy**
Fed	113	36	10	67
	100%	32%	9%	59%
ECB	250	128	19	103
	100%	51%	8%	41%

Notes: This table reports the outcome of a classification of surprises based on the stock-bond correlation and also variance of yields with different maturities at the time of the monetary policy announcement at different maturities in the yield curve. The approach follows Cieslak and Schrimpf (2019), and allows to distinguish monetary policy announcements based on the dominant economic news components into news related to 'growth', 'risk' and 'monetary policy' itself. The sample period, due to data availability runs until December 2017.

Table IA.6: Financial Links and Spillovers: Robustness with Additional Measures

	Advanced economies				Emerging market economies			
	Target	Path	Long-rate	R^2	Target	Path	Long-rate	R^2
Chinn-Ito index								
Fed	-0.16	-0.04	-0.11	15%	-0.06	0.20	0.04	6%
	(-1.50)	(-0.75)	(-1.85)		(-0.25)	(1.62)	(0.35)	
ECB	0.17	0.22	0.25	14%	0.10	0.09	0.14	0%
	(1.52)	(2.50)	(1.96)		(0.31)	(0.34)	(0.40)	
Portfolio assets								
Fed	0.07	0.05	0.05	15%	-0.05	-0.04	0.01	6%
	(1.52)	(2.02)	(1.38)		(-0.45)	(-0.83)	(0.21)	
ECB	0.09	0.05	0.09	14%	0.00	-0.03	-0.01	0%
	(2.79)	(2.13)	(2.98)		(0.00)	(-0.49)	(-0.07)	
FDI assets								
Fed	0.06	0.05	0.02	15%	-0.01	-0.04	-0.04	6%
	(1.50)	(2.22)	(0.87)		(-0.08)	(-0.56)	(-0.56)	
ECB	0.09	0.07	0.09	14%	-0.01	-0.05	-0.03	0%
	(3.07)	(3.17)	(3.87)		(-0.08)	(-0.55)	(-0.24)	
Debt assets								
Fed	-0.03	0.01	-0.01	15%	-0.11	-0.59	-0.14	7%
	(-0.90)	(0.41)	(-0.56)		(-0.21)	(-3.25)	(-1.05)	
ECB	0.06	0.04	0.07	14%	-0.21	-0.28	-0.27	0%
	(2.56)	(2.08)	(2.65)		(-1.35)	(-1.70)	(-1.43)	
Financial derivatives								
Fed	0.04	0.09	-0.01	15%	0.03	0.02	-0.01	6%
	(0.66)	(2.79)	(-0.57)		(0.28)	(0.36)	(-0.46)	
ECB	0.07	0.05	0.07	14%	-0.06	0.02	0.00	0%
	(2.70)	(2.25)	(3.02)		(-0.89)	(0.40)	(0.04)	
Portfolio liab.								
Fed	-0.01	0.00	-0.02	15%	0.23	0.09	0.11	6%
	(-0.28)	(-0.12)	(-0.86)		(1.46)	(1.14)	(1.33)	
ECB	0.08	0.04	0.05	14%	-0.03	-0.03	0.01	0%
	(2.79)	(2.14)	(1.93)		(-0.18)	(-0.20)	(0.04)	
FDI liab.								
Fed	0.07	0.05	0.03	15%	-0.16	0.01	0.01	6%
	(1.84)	(2.65)	(1.31)		(-1.13)	(0.15)	(0.08)	
ECB	0.06	0.05	0.08	14%	0.14	0.07	0.08	0%
	(2.43)	(2.69)	(3.40)		(1.10)	(0.63)	(0.77)	
Debt liab.								
Fed	-0.04	0.02	-0.01	15%	-0.10	0.04	0.03	6%
	(-1.08)	(0.98)	(-0.52)		(-0.43)	(0.38)	(0.27)	
ECB	0.07	0.05	0.08	14%	0.04	-0.04	-0.02	0%
	(2.36)	(2.08)	(2.55)		(0.15)	(-0.17)	(-0.06)	
Financial derivative liab.								
Fed	0.04	0.09	-0.01	15%	-0.02	0.00	-0.01	6%
	(0.66)	(2.79)	(-0.57)		(-0.15)	(0.01)	(-0.43)	
ECB	0.07	0.05	0.07	14%	-0.06	0.01	-0.03	0%
	(2.70)	(2.25)	(3.02)		(-0.91)	(0.08)	(-0.29)	

Notes: This table reports the results of panel regressions as given by Equation (2) with various recipient specific conditional variables $X_{i,t-1}$ measuring bilateral financial openness going beyond those used in the main text. The dependent variable is the daily change in 10-year bond yields in our set of 47 recipient countries. The analysis is performed separately for advanced economy vs emerging market economy recipients. As regressors, besides the monetary surprises for the ECB and the Fed, specifications also include the daily change in the US Treasury yield and the VIX as global controls (coefficients not reported). The reported coefficients correspond to the interaction term, $\hat{\gamma}_j$, in (2). t-statistics from Panel Corrected Standard Errors (PCSE) are given in parentheses. Cells coloured red (green) indicate statistically significant positive (negative) coefficients at a 10% confidence level. Financial flows (% of GDP) are measured in standard deviations from the mean.